Manufacturing Technology
USAF

MANTECH PROJECT BOOK

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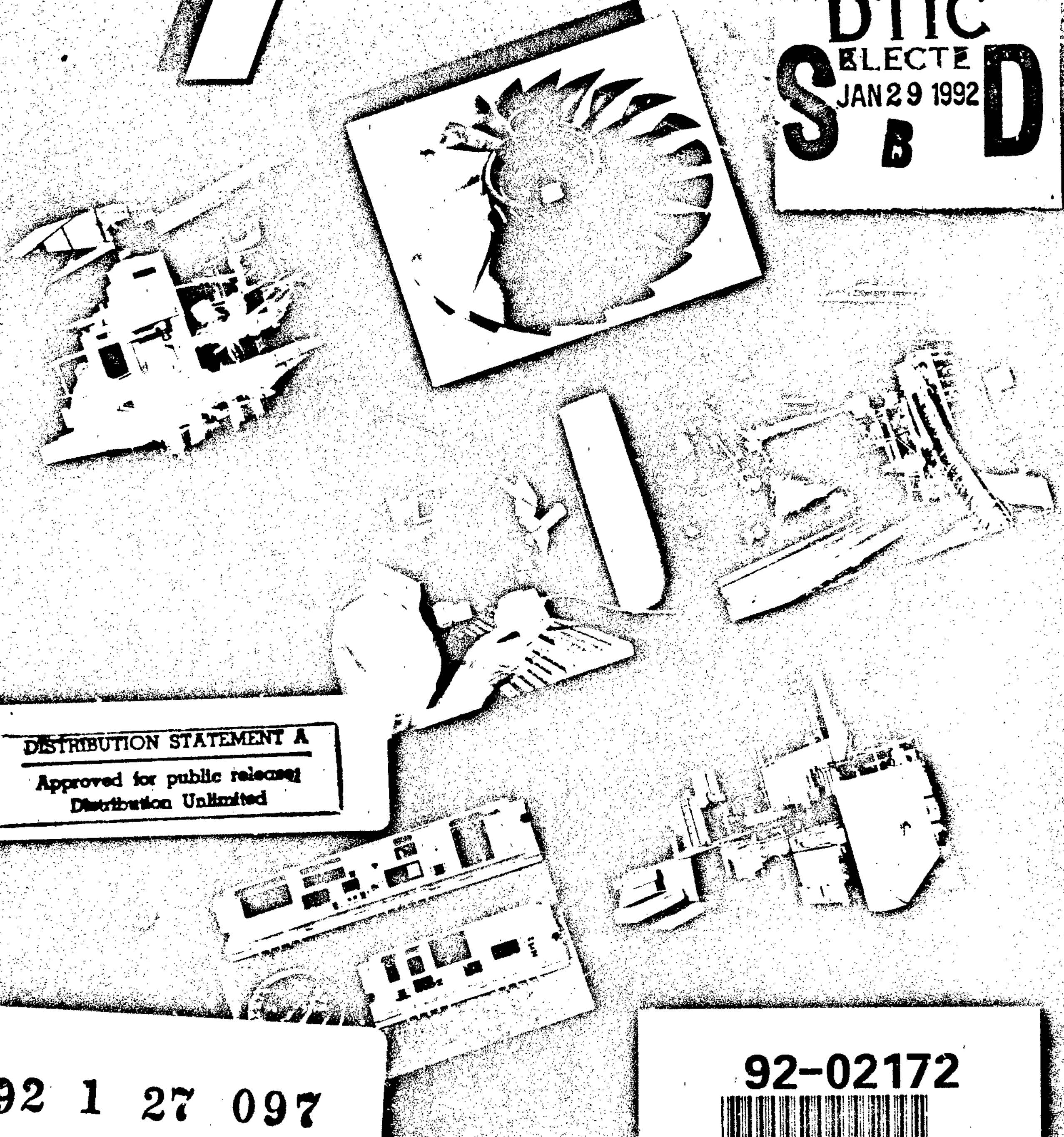

APPROVED FOR PUBLIC RELEASE

The Manufacturing Technology Program Status Reports are designed to inform you of significant accomplishments, forthcoming events of widespread interest, and to expedite direct exchanges between government and industry management concerned with broadbased MANTECH activities. Recipients are encouraged to route the Status Report to associates and other organizational functions engaged in MANTECH program activities. All comments relating to this Status Report should be directed to the WL/MT (Program Status Report), Wright-Patterson AFB OH 45433-6533.

FOREIGN DISSEMINATION

Details regarding many specific MANTECH programs are subject to special export controls. Therefore, follow-up from any foreign source should be processed through embassy channels following normal procedures for request of technical information or technology transfer.

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REPAIR TECHNOLOGY

MANTECH PROJECT BOOK

This book provides a summary of the projects the Air Force Manufacturing Technology Directorate has in progress or has completed within the last ten years. Its purpose is to promote the transfer of the technology which was developed through these investments into the defense industrial base.

Each project has been summarized on a single page which contains an explanation of the need for the project, the approach taken to accomplish the effort, the benefits expected to be realized, the current status, who the project engineer is, and the performing contractor. In some cases, where there have been a multitude of small efforts with a common theme, the descriptions have been briefer and combined together. The project descriptions have been written in layman's language in order to promote understanding in the widest audience possible. The intent is to enable the reader to determine if the project could be useful and then provide more detailed technical information upon request.

This book is intended to be a "living" document and, as such, updates in the form of slip pages will be provided quarterly to those who request them. The entire document will be updated annually.

Organizations and individuals wishing to obtain updates or additional information on any of the MANTECH programs outlined herein, or any other MANTECH program, should submit a formal letter of request, specifying which programs or technical report(s) are of interest to this address:

MANTECH Technology Transfer Center
WL/MTX
Wright-Patterson AFB, OH 45433-6533
PHONE: 513-256-0194
FAX: 513-256-1422

Requests are limited to one copy of each document ordered per address. Additional copies of these reports should be requested from the Defense Technical Information Center at this address:

Defense Technical Information Center
DTIC-DDRA
Cameron Station
Alexandria, VA 22314
PHONE: 202-274-7633

Details regarding many specific MANTECH programs are subject to the Arms Export Control Act (Title 22, U.S.C., Sec 2571, et seq) and International Traffic-in-Arms Regulations (ITAR). Therefore, requests from foreign sources should be processed through embassy channels following normal procedures for request of technical information or technology transfer. Domestic and Canadian organizations must have an approved Military Critical Technical Data Agreement (DD 2345) filed with the U.S./Canada Joint Certification Office prior to release. To verify your organization's certification or to obtain an application you may call the Certification Office at 1-800-352-3572.

MANUFACTURING TECHNOLOGY DIRECTORATE

Since its inception in 1947, the goal of the Air Force Manufacturing Technology (MANTECH) program has been to enhance productivity, increase quality, and reduce life-cycle cost of weapon systems. Contractual projects are application oriented, designed to demonstrate, validate, and implement manufacturing processes for use by the aerospace industry and the Air Logistics Centers of the Air Force Logistics Command.

MANTECH investments address high-payoff problem areas in all industry sectors producing and repairing weapon systems and support equipment for the Air Force (AF). Problems addressed are generic in nature, applicable to virtually all manufacturers in any industry sector and to multiple weapon systems. Efforts address all levels of industry from large prime contractors to material and parts vendors as small as 20 person shops.

MANTECH investments are made to accelerate and broaden implementation of production concepts and techniques proven feasible in the research and development community. Contracts are awarded to private industry on a competitive basis and provide focus, direction, and "seed money" in manufacturing technology areas that offer potentially high payoff but are beyond the normal risk for industrial investment. High payoff can be measured not only in direct production savings but also in quality which improves safety, serviceability, and readiness. Projects funded by MANTECH generate and disseminate technical information and technical knowledge. Industry, however, is responsible for direct implementation costs and capital equipment procurements.

The Wright Laboratory's Manufacturing Technology Directorate (MT) is organized into four divisions: Electronics, Integration Technology, Processing and Fabrication and Industrial Base Analysis; and three offices: Concurrent Engineering, Business Integration, and Defense Production Act.

The Electronics Divisions (MTE) consists of the Components Fabrication and Assembly Branch, which pursues Air Force needs in solid state microwave systems, microwave tubes, infrared detectors and other energy conversion components, and the Materials and Device Processes Branch, which manages programs in semiconductor materials, digital integrated circuits, interconnections, inspections and tests.

The effective integration of processes, systems, and procedures used in the production of aerospace systems using computer technology is managed by the Integration Technology Division (MTI). Under its auspices are the Information Management Branch, which is actively involved with information management, information sciences and integration, and the Implementation Branch, whose technology areas include computer integrated manufacturing, engineering design, operations research, and material handling and assembly. The Integration Technology Division combines design, manufacturing, and supportability functions within the same organization.

The Processing and Fabrication Division (MTP) manages programs to improve structural and nonstructural materials processing and fabrication. Within this Division, the Metals Branch directs the manufacturing methods program for metals and metal matrix composites processing and fabrication. The Nonmetals Branch directs the manufacturing methods programs, which include all manufacturing processes for producing and utilizing propellants, plastics, resins, fibers, composites, fluid elastomers, ceramics, glasses, and coatings.

The objective of the Industrial Base Analysis Division (MTA) is to act as focal point for the USAF industrial base program for productivity, responsiveness, and preparedness planning. They coordinate annual Air Force Systems Command and Air Force Logistics Command data into the U.S. Air Force production base analysis, recommend investment strategies for the MANTECH element, and provide industrial base analyses and technical assistance.

The Concurrent Engineering Office (MTR) plans, initiates, coordinates and manages programs addressing Integrated Product Development (IPD) which span a broad spectrum of disciplines, including engineering design, manufacturing, quality assurance, and logistics support. This office is also responsible for managing the Manufacturing Science program for the Directorate which focuses on establishing a science base from which to transition new technologies for further refinement by the Manufacturing Technology programs.

The Business Management Integration Office (MTX) coordinates and consolidates the investment strategy for the Manufacturing Technology Directorate. This office also plans, coordinates, and manages the Repair Technology Program (REPTECH), provides technical guidance in the evaluation of proposed Industrial Modernization Incentives Program (IMIP) projects, and is the manager of MANTECH's technology transfer and benefits tracking programs.

The Defense Production Act Office (MTD) serves as the program office for Air Force Title III programs, which establish or expand domestic production capacity for materials that are considered critical to DOD. Title III accomplishes this by providing domestic industry with incentives in the form of purchases and purchase commitments for materials.

With regard to future directions, the MANTECH Program will balance near-term and longer-term technical requirements for the manufacturing of Department of Defense (DoD) and Air Force systems. The Manufacturing Technology Directorate expects to continue its long standing track record of providing high return on investment technologies in the production and repair of Air Force weapon systems.

INTEGRATED PRODUCT DEVELOPMENT FOR ADVANCED NOZZLE

CONTRACT NUMBER: N/A

STATEMENT OF NEED

Historically, weapon systems have been designed with primary focus directed to performance parameters and with little consideration for producibility, reliability, maintainability, supportability or cost. Downstream issues of manufacturing and support are addressed after critical technology decisions have been made. This sequential design approach leads to expensive engineering changes when high performance designs are deemed unproducible. Unproducible and unreliable designs drive up system life cycle costs. Integrated Product Development (IPD) is a design approach to concurrently develop products and their related processes, including manufacturing and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal including quality, costs, schedule and user requirements. The IPD approach addresses not only technical issues but cultural/business issues as well. These cultural issues focus on bringing the manufacturing, reliability, maintainability, and supportability disciplines into the earliest product design phases.

Two dimensional (2D) nozzles used for vectoring jet engine exhaust show great promise for increasing the performance of future aircraft. By essentially becoming part of the aircraft control system, 2D nozzles divert the flow of exhaust in a concentrated manner to maneuver the aircraft, thereby reducing the surface area drag penalty required for aerodynamic controls. A prototype version of a 2D nozzle is being flight tested on an F-15 and is the technology baseline for the F-22 and other aircraft designs which rely upon STOL/VSTOL (Short Take Off and Landing/Very STOL) capabilities.

The performance benefits of the 2D nozzle also have companion weight, cost, and supportability challenges to overcome. The current prototype articles are fabricated from complex titanium and welded sheet nickel components. These construction techniques require an extremely large number of specialized tools and expensive facilities for fabrication. Furthermore, the actual weight and cost of prototype models far exceed the original estimates and the supportability issues have not been adequately addressed to date.

The objective of the Advanced Capability Exhaust Structure Integrated Product Development (ACES/IPD) program focuses on incorporating IPD principles into the exhaust nozzle advanced development technology process to insure smooth transition to engineering development products, decreased development time, reduced life cycle costs, and increased system quality.

APPROACH

This is a three phase program to develop and demonstrate the IPD approach for advanced exhaust nozzles. The effort will conduct a comprehensive survey of past advanced exhaust system design and development experiences; nozzles such as the S/MTD, ATFE prototype, and others will be researched. A lessons-learned guide for future nozzle development will be prepared. Guidelines for the application of IPD and quality engineering tools for advanced nozzles will be recommended. These guidelines will be incorporated, demonstrated, and refined either in technology areas proposed in the ACES Advanced Nozzle Technology Issues proposal, or in other suitable nozzle technology applications. The information gathered will guide the definition of a mature technology data package to facilitate the transition of technologies from concept to product lines.

BENEFITS

- Lowered weapon system life cycle costs through development of more producible, reliable and maintainable designs.
- Improved transition from 6.3/7.8 advanced technology development programs to 6.4 engineering development programs.
- Identification of gaps in manufacturing process technologies.
- IPD methodology for advanced nozzles in place for Wright Laboraories Pilot Nozzle Program. This task impacts nozzle development for future aircraft including Multi-Role Fighter (MRF).

STATUS

Pre Award
Award Date - September 1991

RESOURCES

Project Engineer: James Poindexter,
WL/MTR(513)255-8589
Contractor: TBD

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

OPEN ARCHITECTURE FOR ELECTRONIC DESIGN AND SUPPORT TOOLS

CONTRACT NUMBER: F33615-90-C-5936

STATEMENT OF NEED

Computer systems, other electronic systems. and even mechanical systems are becoming increasingly complex. Because of this complexity, it has become essential to develop automated tools to assist the designer. There are many commercial products which provide aids for the design and validation problem. There are systems which help establish the reliability and testability of a current design. There are products which help generate self testing approaches for systems, and there are wide ranges of automatic test equipment. None of these products interoperate in an integrated manner. One set of commercial tools cannot be easily used to confirm the results of another because they use different representations of the design, different definitions of values, and different output formats. There is a natural hierarchy of evaluation of reliability, testability, and diagnosability and there are different tools that operate at different levels of that hierarchy, but current tools cannot pass the results of one level of evaluation to the next level of analysis. This effort addresses this critical issue - the interoperability of existing and future design and maintenance tools.

The objective of the Open Architecture for Electronics Design and Support Tools Small Business Innovative Research (SBIR) program is to facilitate Integrated Product Development (IPD) by creating an open architecture, based on the C I layering scheme, that allows different electronics testability and maintainability (T&M) tools to interoperate. This program also intends to provide the standardization of the proposed architecture, through sponsorship by the IEEE SCC20 standards committee.

APPROACH

This program will develop and demonstrate an open layered architecture for electronics design and support tools that specifically includes dependency data, ambiguity group data and fault tree data layers. The effort will refine and develop EXPRESS models for the above data categories.

These data model layers will be incorporated into the Test Strategy Layer of the overall Ada-Based Environment for Test (ABET) architecture standard being developed by IEEE SCC20. In addition to developing data models, this effort will develop a dependency data interchange format based on ISO CD 10303, and pre/post processors to convert Dependency,Ambiguity Group and Fault Tree data to/froma standard data model using this interchange format. Data models and interchange formats will be verified using commercial electronics analysis tools. This effort will coordinate with the SCC20 standards committee.

BENEFITS

- Interoperability of design and maintenance tools.
- Standardized architecture for industry - wide use.
- A smaller suite of diagnostic tools, thus resulting in significant cost savings to both government and industry users.

STATUS

Active
Start Date - August 1990
End Date - February 1991

RESOURCES

Project Engineer: James Poindexter,
WL/MTR (513) 255-8589
Contractor: Intelligent Automation, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

DECISION SUPPORT SYSTEM / LIFE CYCLE ENGINEERING

CONTRACT NUMBER: F33615-89-C-5700

STATEMENT OF NEED

In 1987, Ramsearch was awarded two U.S. Air Force Small Business Innovative Research (SBIR) Phase I contracts. Under these two contracts, Ramsearch developed and delivered to the U.S. Air Force software prototypes of a new approach to concurrent engineering design evaluation and optimization. The results of Phase I received extremely favorable reviews and Ramsearch was awarded Phase II SBIR contracts to expand the proof-of-concept software into production level tools. The result of the Phase II contracts is Team/Design,™ one of the first commercially available concurrent engineering design and analysis software products.

Team/Design is an object-oriented, knowledge-based tool for concurrent engineering design of complex and simple systems. It supports program managers in the high-level design engineering and resource allocation aspects of project management in pre-proposal, preliminary, and later stages of product design. Team/Design supports systems engineers and speciality engineers in creating and modeling alternative designs in many domains, including both electrical and mechanical systems. It enables designers, individually or as a group, to consider and tradeoff multiple design goals, specifications, and constraints.

The objective of this program is to determine design requirements for a life cycle engineering workstation, and develop a candidate design/decision support software system for military use.

APPROACH

Design Presentation System: The unique and innovative design-object representation graph presents the design in a hierarchical collection of object-oriented design entities. It allows manipulation of design variables associated with objects of each design class (which contain information about design constraints and rules regarding the composition of the design objects).

Allocation of System Requirements: Design specifications, goals, and constraints may be allocated to all objects (systems, subsystems, assemblies, and components) represented in the design. These allocations of requirements and goals are a key ingredient for Team/Design's decision support capabilities. As more detail is added to the design through refinement, allocations may be assigned to successively greater levels of design detail.

Design Evaluation: Each design object contains information on methods for calculating relevant design attributes. Analysis of a design with respect for the requirements of each attribute may be conducted even at the earliest stage of the design process when very little detail has been decided. As with allocation, more detail evaluations may be performed as the design progresses. Potential problems (such as cost overrun, insufficient, reliability, unbalanced manufacturing/delivery lead times, inadequate performance) are recognized at an early stage and correctable at minimal expense.

Data Base Management: The multi-user, object-oriented database allows for simultaneous access to the same design by a team of designers. Uniformly quick retrieval of any part of the design is ensured by a design data caching technique.

Team/Design is written in the object-oriented language C++ and runs on the Unix operating system on Sun Microsystem workstations. It uses the X-Window System Version II, Release 4 window management system and the Quest InterViews/Motif C++ toolkits as the foundation for the user interface.

BENEFITS

The flexibility of Team/Design makes it applicable to the design of a wide variety of complex systems. This includes commercial and military electronics, aircraft, shipbuilding, automotive, satellites, missiles, etc. For a relatively small investment in Team/Design, systems builders reap a large payback in decreased life cycle costs and enhanced performance.

Team/Design enhances design decision making in selecting among alternatives in the search for a total quality product design. While its primary application is in the early stages of design, it is useful throughout the product design cycle in organizing and analyzing the impact on the overall complex of choices made in detail design. It includes an integrated expert system shell, multi-goal modeling, graphical tradeoff support, and a cooperative design module to enhance teamwork among engineers.

STATUS

Active
Start Date - April 1987
End Date - July 1991

RESOURCES

Project Engineer: Chuck Wagner
WL/MTR (513) 255-8589
Contractor: Ramsearch Company

INTELLIGENT MACHINING WORKSTATION

CONTRACT NUMBER: F33615-86-C-5038

STATEMENT OF NEED

The requirement for the Intelligent Machining Workstation (IMW) program was based on several observations of the state of U.S. manufacturing in the mid-1980's. These were specifically focused on batch metalworking and included:

- A trend toward decreasing lot sizes, with a size of one not being unusual
- A trend toward increased variety of the parts being produced
- A trend toward increased precision required in parts being produced
- The introduction of new and "exotic" materials

A research and development initiative in the area of small batch manufacturing on computer numerical control (CNC) machine tools was determined to be beneficial in laying a foundation for resolving the problems and issues listed above. The area of focus in the manufacturing life cycle would be from the "operations planning" level down to the actual physical part fabrication.

The goals of the IMW program were defined as follows: 1) Make a good first part fast, 2) Manufacture directly from an electronic part definition, 3) Provide programmable flexible fixtures, and 4) Improve accuracy.

APPROACH

IMW was defined as a four-phase, 42-month program to include developing and testing three prototype Intelligent Machining Workstations. The prototypes would verify the design specifications that would also be determined as part of the program.

The four phases of the program were:

Phase I- Establish needs, requirements, and specifications.

Phase II- Design, build, and test Prototype I, the Advisor. The Advisor would give the user assistance in making the part, but would still be very dependent on operator skill and expertise.

Phase III- Design, build and test Prototype II, the Overseer. The Overseer would automatically perform most of the operations planning and fabrication functions, but would leave exception handling and extremely complex areas to the operator.

Phase IV- Design, build, and test Prototype III, the Unmanned Workstation. The unmanned workstation would be able to produce a good first part fast with virtually no operator intervention.

Phase V- Produce final documentation including final system specification and lessons learned.

A joint Industry/University Review Board (I/URB) was selected to serve as a forum for prioritizing industry needs and assessing industry response to the program.

BENEFITS

The primary benefit of the IMW program was the design and implementation of a prototype system to rapidly generate operations plans for parts, thus providing considerable time and cost savings over current methods. IMW can typically plan a part in 20-40 minutes as compared to days or weeks in many shops.

IMW technology has significant potential benefit for many small lot size, one of a kind, and/or quick turnaround environments, such as model shops and repair/spare parts facilities. The benefits include:

Drastic reduction of "Enterprise Time": The time it takes a manufacturing organization to generate an operations plan for producing a part. This time is typically much greater than the actual on-machine time to execute the plan and produce the part.

First Part Right: The IMW system has been successful at producing a "good first part" for a number of the test parts.

Foundation for Concurrent Engineering: The automated operations capabilities of IMW will make it most useful in a concurrent engineering environment.

Extendable Architecture for Intelligent Manufacturing: The IMW architecture that has been proven can be used as a starting points for other intelligent manufacturing workstation systems.

STATUS

Complete
Start Date -January 1987
End Date - September 1990
Final Technical Report: WRDC-TR-90-8031

RESOURCES

Project Engineer: Chuck Wagner, WL/MTR (513) 255-8589
Contractor: Cincinnati Milacron Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

RAPID PROTOTYPING FOR ELECTRONICS FABRICATION

CONTRACT NUMBER: N/A

STATEMENT OF NEED

Current practice in designing electronic components is performance oriented and seeks to increase speed and complexity of chip sets by combining more functions together on single dies. This requires decreasing geometries and larger die size on wafers. As a result, yields are decreasing and the cost of these components are increasing dramatically. These problems dictate that the designer must consider cost, yield, packaging, and interconnect tradeoffs early at the system level. A balance between system performance and downstream manufacturing fabrication must be considered early in the conceptual design phase to be effective. The designer must have access to key electronics packaging attributes when the behavior modeling of the circuit is partitioned to a particular architecture and a die configuration is selected. This approach is needed to increase overall system yield, improve quality, and thereby reduce system cost for complex multi-chip configurations.

APPROACH

This program will develop a singular product and process representation that can allow for logical, functional, and physical views of the electronic design and can support the concurrent consideration of manufacturing processes, cost, yield information, interconnect strategies, behavior and synthesis information as the circuit evolves from high-level functional description to a physical implementation. This effort will create a generic approach that can characterize how to manufacture a complex circuit that works with available design synthesis tools. This effort will use an independent contractor to develop requirements from across the community, an assessment of what gaps there are in the knowledge base, develop commonalities, and guide implementations that would be extensions of current commercial Electronics Computer Aided Design (ECAD) frameworks. The end product would be a vendor independent data package with information needed to fabricate the packaging system.

BENEFITS

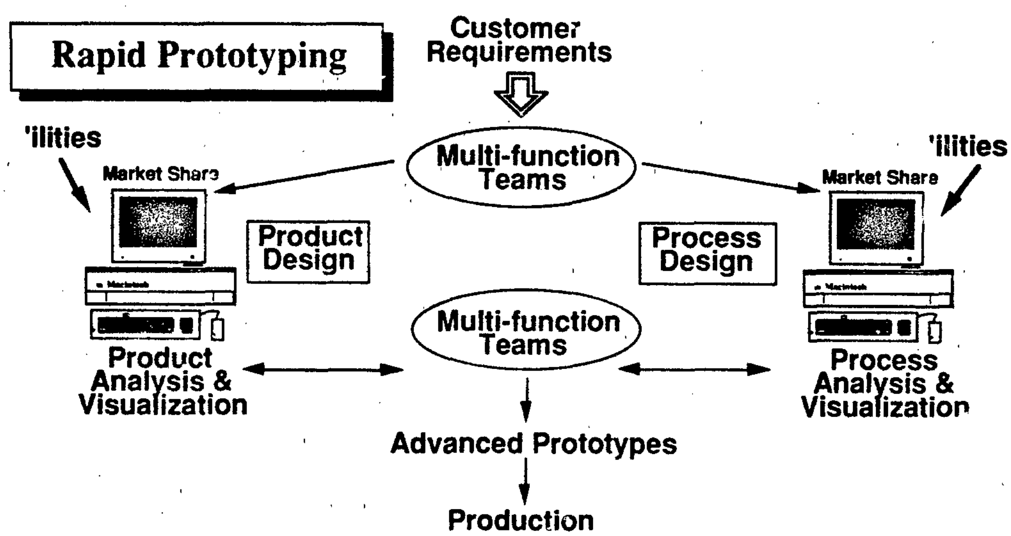
The major benefits of this program are to demonstrate joint design/manufacturing efforts early in the product cycle and to influence commercial vendors.

STATUS

New Start
Start Date - August 1992
End Date - January 1995

RESOURCES

Project Engineer: Chuck Wagner
WL/MTR (513) 255-8589
Contractor: TBD



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

RAPID PROTOTYPING FOR SMALL MANUFACTURED PARTS

CONTRACT NUMBER: N/A

STATEMENT OF NEED

Rapid Prototyping has been used to describe the process of establishing the feasibility of a product before initial fabrication or production. The first commercial system to generate three-dimensional models directly from computer-aided design (CAD) tools was the stereolithography system from 3D Systems. A prototype application of this technology was used to solve a unique interference problem involving a B-52 brake pedal at an Air Logistics Center.

Stereolithography was used to produce form and fit models of the pedal redesign and the design shortcomings were discovered. A cost savings of $500K was realized since production of the retrofitted part was not started until a good brake pedal design was confirmed using rapid prototyping. Since alternative prototyping techniques were not used (i.e. machining), a potential time savings of six to eight weeks was realized. This type of Rapid Prototyping technology is needed across all services where complex parts are being designed to eliminate similar downstream errors.

The objective of this program is to integrate rapid prototyping technology into an Integrated Product Development design activity. The intent is to have Rapid Prototyping accessible to the design team as a seamless part of the product and process development activity to promote communication between the different functions. The intent of Rapid Prototyping is to identify and to correct design related manufacturing problems early in the development process. Engineering changes at this time in the development cycle are low and early consideration of fabrication issues will avoid downstream changes and more expensive life-cycle costs.

APPROACH

The program will facilitate the use of Rapid Prototyping technology for small lot production peculiar to the military market. Examples of rapid prototyping technologies that are available are stereolithography, laser-scintering, and laminated object manufacturing. This effort will examine the feasibility of using rapid prototyping to generate visualization models that can communicate form/fit/function part representations in an efficient manner between design team members. It will develop the associated costs and risks associated with each type of Rapid Prototyping technology and promote the use of Rapid Prototyping technology to determine the type of material processing that is the optimum way to fabricate a given part. This would include process technologies such as welding, casting, or powder metallurgy. This effort will develop a Rapid Prototyping environment to produce complex product descriptions directly from CAD tools and determine the best way to fabricate the required parts in a small-lot, multi-tiered sub-contractor environment that is currently in place to produce parts for DoD.

BENEFITS

The technology developed in this program will shorten and improve the small manufacturing parts development time and quality.

STATUS

New Start
Start Date - July 1992
End Date - August 1994

RESOURCES

Project Engineer: Chuck Wagner
WL/MTR (513) 255-8589
Contractor: TBD

ADVANCED DATA/SIGNAL PROCESSING

CONTRACT NUMBER: F33615-85-C-5065

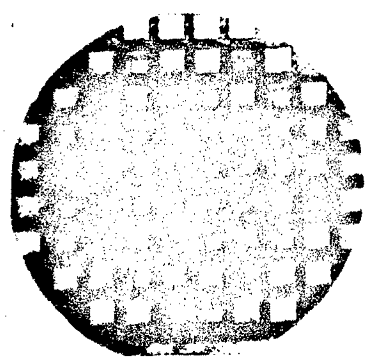
STATEMENT OF NEED

The development of very large scale integrated circuits (VLSIC) and very high speed integrated circuits (VHSIC), coupled with the need for increased signal processing capability, has created the requirement for multi-layer circuit boards with high interconnect density and surface-mounted components. Manufacturing methods to produce such a printed wiring assembly were required before emerging phase I VHSIC chips could be inserted into Air Force weapon systems.

This program addressed a critical need in the implementation and utilization of DoD VHSIC 1.25 μM device technology into weapon systems hardware. Both industry and DoD communities identified electronics integration and packaging (Printed Wiring Boards [PWBs] and solders) as key needs for VHSIC implementation. The implementation of VHSIC is a high DoD priority item and cannot occur without an economical method for chip screening, availability of multilayer printed wiring boards with high interconnect density, and reliable solder techniques to surface mount VHSIC on PWBs.

APPROACH

This program was an integrated, comprehensive effort divided into three concurrent technology tasks, followed by an integration/demonstration task. Task I, "VHSIC Chip Screening and Inspection," established chip fabrication technologies in the areas of in-line data collection with real-time process control, test structures, and correlated radiation screening. Task II, "VHSIC PWB Fabrication," established the design, materials, processes, equipment, and process-control methodology needed to fabricate high-density, high speed, VHSIC PWBs. Task III, "Solder Process Control," was to define the design and process parameters necessary to attain a reliable, high performance solder interconnection system for VHSIC and VHSIC-like electronic systems capable of withstanding 1000 thermal cycles from -55° to +125°C. The final task, "Integration/Demonstration," brought together the material and process technologies from the first three tasks to establish three final module designs and design limits for system insertion, and demonstrated the insertion of high-speed electronic assemblies fabricated using the new enabling technology.



BENEFITS

Financial benefits have been identified and quantified by the contractor. Using a chip cost model established on the project, VHSIC chip costs were calculated as $2,336 initially and $394 based on the technologies establshed in Task I for a cost savings of $1,942 per chip. This equates to a $631 million potential cost savings for 1990 through 1994. Cost savings for Task II for the five year period from 1990 through 1995 are estimated at $41.7 million per year for a total savings exceeding $208 million. Combined total savings for this program exceed $839 million for an expenditure of $22 million, yielding a return on investment of 38:1.

STATUS

Complete
Start Date - January 1986
End Date - June 1990
Final Technical Report: WRDC-TR-89-8025, Volumes I-VI

RESOURCES

Project Engineer: Tony Bumbalough
WL/MTEM (513) 255-2461
Contractor: Martin Marietta Missile Systems

ELECTRONICS

ELECTRONICS MANUFACTURING PROCESS IMPROVEMENT (EMPI)

STATEMENT OF NEED

The Electronics Manufacturing Process Improvement (EMPI) program is a multi-year program to enhance the producibility of electronic components and assemblies through enhanced process control using the quality technologies. The primary objective is to promote the application and implementation of electronic manufacturing processes that support the Department of Defense electronics industry sector. Innovative applications of process controls to improve the quality of materials, components, processes, tests, and assemblies used in the manufacture of Air Force systems are being pursued.

Five contracts were awarded under this effort which satisfy the objectives of this program. The contractors will implement the improvements gained as a result of the effort of the EMPI programs. They will also provide a means for transferring the technology that produced those improvements to others within the same industry. The resulting benefits to the Air Force, the contractor, and the industry are in the following areas: improved product reliability, improved process controls, reduced product costs, or reduced cycle time.

The individual programs will rely heavily on the team process and use much techniques as Statistical Process Control (SPC), Design of Experiments, (Taguchi and classical methods) Quality Function Deployment, Variability Reduction, cause and effect analysis, and flowcharting. Measuring the success of the program will involve establishing a baseline for the application and process selected and then tracking the progress. These programs are all active with completions occuring throughout 1992.

Electronics Manufacturing Process Improvements for PWA
Contract Number: F33615-90-C-5006

This program will rely on the team process and use Design of Experiments (DOE) in order to improve the printed wiring assembly line. Measuring the success of the program will involve establishing a baseline before conducting the DOE, running the experiment and then comparing the results of the baseline to determine the benefit of the effort.

Reliability will be improved by reducing the amount of boards rework and improved solder joint formation and reduced solder joint variability.

Project Engineer: Robert Cross
WL/MTEC (513) 255-2461
Contractor: TRW - Mead (Military Electronics & Avionics Division)

Low Cost Fabrication of GaAs Monolithic Microwave Integrated Circuits
Contract Number: F33615-90-C-5013

The production of the advanced active phased array radar systems create a demand for high volume production of gallium arsenide (GaAs) monolithic microwave integrated circuits. GaAs MMICs are extremely important to the defense industry because of their broad usage in microwave systems and to ensure the success of active aperature radars.

This program will demonstrate the implementation of Quality Function Deployment (QFD) and the reduction of the cost and variability of a GaAs low noise amplifiers (LNA) MMIC (Improvement of quality materials, components, processes, and tests in its manufacturing facility for GaAs LNA MMICs).

Not only will the methodology for variability and cost reduction be demonstrated but, the mechanism for transfering this technology to others in the Defense electronics industry sector will be provided in the form of government/industry workshop.

Project Engineer: Wallace Patterson
WL/MTEC (513) 255-2461
Contractor: Varian Associates

ELECTRONICS MANUFACTURING PROCESS IMPROVEMENT (cont)

X - Ray Laminography as a Process Control Tool
Contract Number: F33615-90-C-5007

The objective of this program is to establish X-ray laminography as a process control tool for the manufacturing of surface mount solder joints. The capability of laminography to measure the volume of solder will be characterized, cause and effect relationship between solder volume and critical process parameters will be determined, and designed experiments will be conducted to optimize the process and improve process capability.

The test vehicle will be a surface mount printed wiring assembly (SMTPWA) which contains leaded chip carriers and chip capacitors.

Project Engineer: Troy Strouth
WL/MTEM (513) 255-2461
Contractor: Texas Instruments, Inc.

Electronics Manufacturing Process Improvement for Fiber - Optic Gyro
Contract Number: F33615-90-C-5011

The objective of this program is to optimize the automated coil winding station design and winding process parameters through the application and implementation of statistical techniques.

The cost of the coil winding is a significant portion of the overall cost of Fiber Optic Gyro (FOG). By automating this operation, this program will significantly impact the cost of inserting FOGs into systems.

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Litton Systems, Inc.

Advanced CMOS Gate Dielectric Thin Films
Contract Number: F33615-90-C-5010

This application of Statistical Process Control (SPC) is to improve the manufacturability of oxide-nitride-oxide (ONO) thin films required for radiation hardened, high reliability complementary metal-oxide semiconductor (CMOS) circuits.

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: TRW - Electronic Systems Group

MANUFACTURING TECHNOLOGY FOR FIBER OPTIC EMITTERS

CONTRACT NUMBER: F33615-84-C-5011

STATEMENT OF NEED

Military communications which presently use telephone cables or coaxial cables are very bulky and heavy (weighing many tons for an army division command post). They are vulnerable to nuclear effects. There is a need to replace present cable-based systems with fiber optics based systems. These should meet environmental Mil Specs, should be small and light for mobility, should handle high digital and analog data rates over distances of several miles without the need for repeaters, and should be radiation-hardened and electromagnetic pulse resistant. Presently available commercial components are not suitable.

The objective of this program is to meet the need for a Mil-Spec emitter (transmitter) module. The Army (Fort Monmouth) is addressing the need for a receiver module. Both services will use the same components in different systems; the immediate applications to be the Army Fiber Optic Transmission System (FOTS) and a new Air Force Tactical Air Control Center.

APPROACH

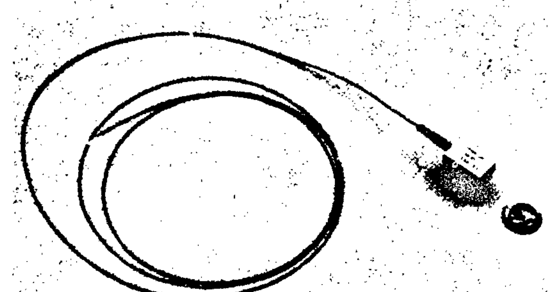
Phase I, 8 months, demonstrated that the module meets specifications, and Phase II, 8 months, demonstrated a pilot line capability to produce satisfactory modules at a rate of at least 40 per week.

During Phase I, the contractor optimized the design parameters and growth conditions for the edge-emitting Light Emitting Diode (LED). The effort focused on the power-injection current relation, which was not the same over the specified temperature range. The device was linear only at room temperature. Much of the work during Phase I went into redesigning the LEDs in order to obtain the linear behavior over the wide temperature range required for military operation.

In Phase II, the contractor verified the manufacturing techniques developed in Phase I by establishing and demonstrating a pilot production line. The devices were fabricated, and reliability studies were performed. During Phase II emphasis was placed on mechanical package stability of the module. This required fiber stability along the optical axis of the LED, coupled with good solder joint integrity of the pigtailing shelf assembly. Testing was performed on the modules, and a total of 73 devices were delivered

BENEFITS

Program accomplishments include improvements in linear characteristics over the specified temperature range, a more efficient and reproducible coupling between the LED and optical fiber, better package production yields, an improved assembly throughput, an upgraded module reliability, and a reduction in unit cost by a factor of two.



STATUS

Complete
Start Date - January 1985
End Date - April 1990
Final Technical Report: WRDC-TR-90-8013

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: M/A Com Laser Diodes, Inc.

MANUFACTURING TECHNOLOGY FOR A MICROCOMPUTER FUZE

CONTRACT NUMBER: F33615-81-C-5144

STATEMENT OF NEED

This Manufacturing Technology program was conducted to establish manufacturing processes and controls necessary for the production of an integrated chip (IC) single chip microcomputer. The TA11445 microcomputer chip established on this program provides the capability to implement electronic fuzing functions required in present and future general purpose bombs and munitions. This microcomputer chip utilizes complementary metal-oxide semiconductor (CMOS) technology to address the low power requirement specified on this program.

APPROACH

The scope of the technical effort on this program involved two tasks. Task One dealt with the basic microcomputer circuitry including: Central Processing Unit (CPU), Timer, Registers, Ports A, B, and C, Read Only Memory (ROM), Random Access Memory (RAM), Oscillator, Reset Circuit and other interconnecting functional circuits. These Fundamental Microcomputer functions basically are the same as the CDP68HC05C4 microcomputer, except for Reset Circuit and bit capability of ROM and RAM which were reduced.

Task Two involved incorporation of the Manchester II Serial I/O Port circuitry including Registers, Counter and Encode/Decode circuits. The circuitry established in these two tasks was then integrated into a single chip as required to meet program requirements for the "Microcomputer Fuze".

BENEFITS

This militarized microcomputer incorporates a general purpose design that has the potential to address numerous applications. Some of these applications are listed below:

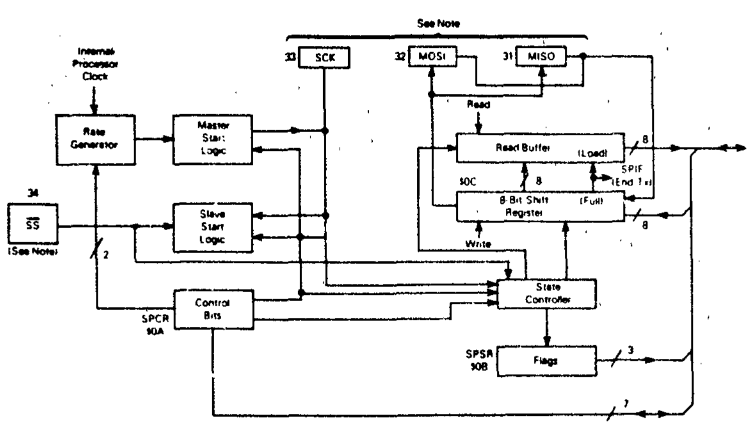
- Product improvement to the FMU-143
- Standardized Avionics Integrated Fuze
- Product inprovement of the FMU-139 Common Bomb Fuze
- Other munitions applications or instrumentation pods

STATUS

Complete
Start Date - March 1981
End Date - August 1990
Final Technical Report: AFWAL-TR-89-8006

RESOURCES

Project Engineer: Jack Garrett
WL/MTEM (513) 255-2461
Contractor: Harris Semiconductor



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR GaAs FIELD EFFECT TRANSISTORS (FETS)

CONTRACT NUMBER: F08635-80-C-0289

STATEMENT OF NEED

The objective of this program was to reduce the cost of gallium arsenide field effect transistors (FETs) suitable for use at X-band by developing and implementing efficient and reliable production processes. This program was aimed in particular at the series of FETs required for Advanced Medium Range Air To Air Missile (AMRAAM). This program was set in motion by a consideration of the number of GaAs FETs that would be required by the AMRAAM missile program in full production. The effort was proposed with the objective of further reducing the total FET cost to $2,500 per missile. This would represent a savings of $50 million over the total projected production run of 20,000 missiles. These cost savings in FET production would also have a significant positive impact on many other programs being planned which would use large numbers of FETs.

In order to achieve these cost savings, every aspect of FET production had to be reexamined with the objective of increasing yield and simplifying assembly and test. The three most important problems that had to be attacked were control of the properties of the epitaxial films, the high yield formation of the very small structures (approximately 1 micron), and reduction in the cost of microwave testing, particularly the largest power FETs. Also, it was not clear at the start whether the largest FETs in the program could be successfully enclosed in hermetic packages for use at X-Band without full internal matching.

APPROACH

This program consisted of two phases. Phase I was concerned primarily with problem definition. The processes being used to purchase GaAs wafers, grow epitaxial films, process wafer to FET dice, and assemble the dice into finished packaged units were reviewed for their applicability to large scale production. If after review the processes did not appear suitable for large scale production, modifications were proposed and tested, and equipment suitable for large scale production was selected and tested. This equipment included improved epitaxial reactors, automatic vacuum deposition systems, and partially automatic assembly and test equipment.

Phase II was concerned primarily with the implementation of the results obtained in Phase I. The effectiveness of the new substrate procurement procedures, the suitability for large scale production of the new epitaxial reactors, and the improved yield of the revised wafer processing procedures were all demonstrated. Phase II also included a demonstration of an unbalanced production line capable of producing 12000 RPX 6037 five watt FETs per month.

The program's main areas of activity were:

- GaAs substrates: a vendor survey, vendor evaluation, and evaluation of availability of material
- Epitaxy: reactor design, growth production problems, and a large scale demonstration
- Device Fabrication and Test: production equipment, process controls, and yields
- Demonstration of the reliability of production FETs
- Packaging: work on hermetic sealing and internal matching at X-band
- Production demonstration showing that the volume goals of the program can be met.

BENEFITS

Benefits from this program include:

- Over 70% reduction in cost for a good finished unit
- Product yields ranging from 46-63%, as compared to previous typical yields of 20%.

STATUS

Complete
Start Date - June 1980
End Date - February 1983
Final Technical Report: AFWAL-TR-84-4081

RESOURCES

Project Engineer: Jack Garrett
WL/MTEM(513) 255-2461
Contractor: Raytheon Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR SILICON-ON-INSULATOR WAFERS

CONTRACT NUMBER: F33615-89-C-5714

STATEMENT OF NEED

Silicon-on-insulator (SOI) technology is being applied to integrated circuit (IC) fabrication and has received great interest for use in military systems where operation in severe radiation environments is required. The utility of this technology for application in military systems has been demonstrated in the past by silicon-on-sapphire (SOS) technology, which has been utilized for fabrication of radiation hardened metal oxide semiconductor (MOS) IC devices. One of the primary disadvantages of SOS technology is that it has been unable to produce bipolar ICs for application in military systems.

This program has been established to advance manufacturing techniques and processes for separation by implementation of oxygen (SIMOX) wafers for use in fabricating complex ICs that will have the capability to operate in severe radiation environments. This SIMOX wafer technology also has the ability to implement bipolar circuits as well as CMOS circuits on the same IC chip. SIMOX wafer technology is a specific SOI approach that implants oxygen ions into a silicon-dioxide layer to enable the desired isolation of the MOS and bipolar transistor circuits contained in the silicon layer above the buried silicon dioxide.

APPROACH

The SIMOX process has been selected as the primary SOI approach. An independent SOI wafer vendor is required as an integral part of this program to supply reasonably priced SOI wafers to the semiconductor industry when the program ends. The wafer vendor has been tasked to produce SIMOX wafers on a high throughput NV-200 ion implanter to minimize the wafer implantation time and to reduce wafer cost by mechanizing the batch processing of the wafers. During this program complex 64K bit static RAM (CMOS technology) devices will be fabricated to demonstrate the SIMOX wafer quality and the capability to produce complex IC devices suitable for use in stringent military radiation environments.

BENEFITS

The program will significantly lower the cost of SOI wafers which are presently priced around $500 per wafer. In addition, benefits will be attained from the increased complexity of the IC devices that can be fabricated for future systems.

STATUS

Start Date- July 1989
End Date- December 1993

RESOURCES

Project Engineer : Jack Garrett
WL/MTEM (513) 255-2461
Contractor: Texas Instruments, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

HOLOGRAPHIC WAFER INSPECTION

CONTRACT NUMBER: F33615-88-C-5442

STATEMENT OF NEED

The requirements of greater functional densities and higher operational speeds for integrated circuits have resulted in large silicon wafers with large die sizes. Silicon wafers have increased from 4 to 8 inches and have become highly complex with smaller feature sizes below 0.5 microns. This push in density and size has necessitated advances in inspection equipment. Historically, the optical microscope has been the primary tool for defect detection and process evaluation. As minumum feature sizes shrink, the inspection magnification must increase, thus decreasing field of view and depth of focus that in turn decreases inspection area for a given inspection time. Existing automated inspection methods are inefficient for present and future wafer technology. Pixel by pixel methods are slow, and light scattering methods are not well-suited for detecting embedded or planar defects. Holographic inspection offers an efficient technique which highlights process signatures over an entire wafer.

The objective of this project is to establish holographic technology as an inspecion technique for silicon integrated circuits.

APPROACH

The technical effort of this program consisted of two major phases. In Phase I, the contractor, National Semiconductor, assessed the application of holographic technology to wafer inspection with respect to pattern complexity and defect resolution limits. Also in this phase, a baseline for yield correlation was established. Phase II was an optimization phase for wafer inspection, including in-process inspection and yield correlation.

Through this program, National Semiconductor evaluated holographic wafer inspection technology by development of holographic wafer inspection system by Insystems of San Jose, California. A hologram of the wafer is used for inspection and serves as a permanent three-dimensional record of process anomalies. Inspection can be performed on-line, in-line, in-process, or off-line in more detail.

A new wafer inspection philosophy is emerging through the success of this program. Unlike the traditional "defect accounting" methods, process improvement emphasis has shifted to the detection of whole wafer defect patterns and process signatures, which can lead directly to specific process problems. Faster and earlier detection of process problems means lower cost and shorter lead times for military devices.

BENEFITS

- Reduced wafer inspection time per area inspected.
- Real-time, in-line process control.
- Early identification of process problems for increased yield and continuous process improvement.
- Extensive transfer of these improvements within the industry.

STATUS

Start Date - September 1988
End Date - August 1991

RESOURCES

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142
Contractor: National Semiconductor Corporation

MICROELECTRONICS MANUFACTURING SCIENCE AND TECHNOLOGY (MMST)

CONTRACT NUMBER: F33615-88-C-5448

STATEMENT OF NEED

Commercial semiconductor process lines are tailored for very high volume manufacturing with each line dedicated to a specific device technology and type. The lines are kept full and the processes continually adjusted to keep yields high. By comparison to the commercial market, the military market is very small. Also, since military devices must operate in severe environments, special designs and processes must often be employed.

As a result of these unique military requirements, devices are produced on special lines that are not run continuously. This sporadic production leads to low yields, high cost, and long turnaround times from design through production. In order to cost effectively meet the military microelectronic market needs, the MMST program is to establish and to demonstrate concepts for semiconductor device manufacture of application specific integrated circuits (ASICs) in relatively low volume during the mid-1990s and beyond.

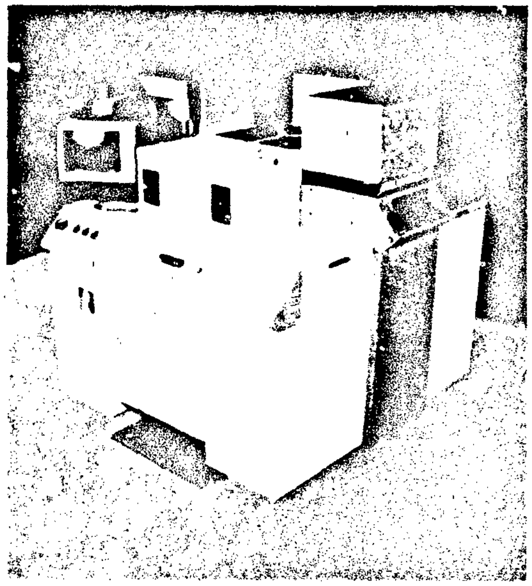
APPROACH

This manufacturing technology program will establish in-situ sensors together with computer-integrated processing and expert system controls on key equipment to demonstrate a flexible microelectronics manufacturing system designed to produce small quantities of complex integrated circuits (ICs) with .35 micron minimum feature size. Emphasis will be placed on transfer of this technology to other domestic semiconductor manufacturers. In order to concentrate the effort on manufacturing, the government will furnish the IC designs for demonstration. This program will ensure the availability and affordability of critical application specific logic ICs for DoD.

Work in the area of process development is highlighted by the conversion of a CMOS process flow to dry, single wafer processing suitable for the MMST modular processing system (MPSs). Two lithography capabilities, DUV and I-line, have been demonstrated for the .35μ geometries. DUV has wider process margins, while I-line has better photoresist. 4K-Gate Demo wafers have begun processing and indicate that processes and equipment are performing well. Software development is continuing for process and factory control. An alpha version of CIM software is scheduled to be completed in early 1992, followed by software/ hardware integration.

BENEFITS

This program will demonstrate the capabiliy of a flexible manufacturing facility with single wafer modular processing systems; dry, vacuum processes; and full automatuon. Such a facility will allow the timely production of affordable, low volume ASIC's for DoD applications.



STATUS

Active
Start Date - September 1988
End Date - June 1993

RESOURCES

Project Engineer: Mary Kinsella
WL/MTEM (513) 255-2142
Contractor: Texas Instruments

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

HERMETIC CHIP CARRIERS WITH COMPATIBLE PRINTED WIRING BOARDS

CONTRACT NUMBER: F33615-82-C-5071

STATEMENT OF NEED

Utilization of surface mount technology, particularly leadless hermetic chip carrier packages on organic printed wiring board substrates, is being hampered by both a structural and thermal incompatibility between the alumina hermetic chip carriers (HCC) and the organic printed wiring board substrate. The intrinsic temperature coefficient of expansion difference between the alumina package, the printed wiring board material, and the copper causes severe mechanical stressing of either the solder joints or the copper in the plated through-hole (PTH) barrel. This results in premature electrical failure of the electrical interconnections. This problem is directly responsible for poor production yields, high production costs, and reliability concerns associated with manufacturing sophisticated Air Force electronics hardware.

This project established and optimized printed wiring board substrate fabrication techniques, materials, and process controls to eliminate and/or reduce the thermal and structural incompatibilities in the solder joints and the plated through-hole barrels. Hermetic chip carrier package assembly techniques and coefficient of thermal expansion matching were addressed to reduce the major stress factors on the solder joints. Stresses in the PTH barrel were reduced via increased copper thickness and larger hole diameters. Successful demonstration of the technology will enhance the reliability and cost benefits of utilizing surface mount technology in Air Force weapon system hardware.

APPROACH

A team of companies; Texas Instruments (prime contractor), Boeing Aerospace, and IBM performed this contract simultaneously. During Phase I a survey of the aerospace industry was conducted to identify and to document potential technology solutions and available, state-of-the-art technologies. Twenty-five candidate technologies were identified and ten of these technologies were selected and studied as likely candidates for surface-mounted devices. Based upon the results of the survey and a finite element analysis, a printed wire board test was configured to mount leadless chip carrier devices and to test the plated through-holes in the boards. There were six types of chip carriers containing 20, 28, 44, 52, 68, and 84 connections. Six daisy-chain circuits were designed to zig-zag through the solder joints. Another 24 daisy chains were incorporated in the design to zig-zag through plated through-holes in the PWB. This board has subsequently become an IPC test standard.

Fabrication, assembly, and solder joint characterization of the ten candidates were performed. The test results demonstrated the value of coefficient of thermal expansion (CTE), matching correlation to solder joint life. As expected, control technologies which did not provide CTE matching showed premature solder joint failures after very few test cycles. Technologies with some CTE matching showed a life cycle in the 300 to 700 range, while those technologies most closely matched demonstrated failure-free performance for over 1000 cycles.

While solder joint life was achieved through CTE matching, an undesired side effect was reduced PTH life.

A strong CTE constraint in the (X-Y) plane of the PWB resulted in an increased out-of-plane (Z-axis) expansion, which was sufficient to stress the PTHs to failure (barrel cracking). PTH failures below 150 cycles were detected on technologies having a low CTE matching, while higher CTE boards demonstrated greater than 800 cycles to first PTH failure.

The program was revised to conduct a more extensive evaluation of PTH life. In addition, the humidity, vibration, and thermal cycle tests were redefined, with temperature cycles to both 100° C and 125° C maximums. A combination vibration/thermal test was also conducted. In addition to the existing test board configuration, two new board configurations were developed.

BENEFITS

The major benefits of this project included a substantial cost reduction in complex/high density electronics fabrication and assembly because of HCC utilization, reduction of costs and labor-intensive operations associated with electronic hardware production, and enhanced reliability to reduce life cycle costs of advanced high technology electronic weapon systems maintenance.

STATUS

Complete
Start Date - November 1981
End Date - December 1989
Final Technical Report: WRDC-TR-89-8055

RESOURCES

Project Engineer: Don Knapke
WL/MTEM (513) 255-2461
Contractor: Texas Instruments, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR IR SENSORS FUZED WEAPON (SFW)

CONTRACT NUMBER: F08635-89-C-0186

STATEMENT OF NEED

This program was identified to establish the manufacturing technologies for rate production or infrared sensors for the Sensor Fuzed Weapon (SFW) system. The objective of the program is to establish the manufacturing techniques, process controls and test capabilities to manufacture affordable SFW infrared sensors at a high production rate. Prior to this effort, the baseline assembly process for the infrared sensors was typified by workers using microscopes, tweezers, and soldering irons and small paint brushes. All operations were highly dependent on the worker's skill, and the production rate was estimated at only 10 units per day.

APPROACH

This program has applied automated or semiautomated techniques to sensor assembly and test steps. Process controls have been established and imrp.'ed techniques introduced for wire bonding and optical coating steps. One example is a pallet system that was implemented to carry eight sensors through several pick-and-place, wire bonding, and testing operations. Not only has this system improved throughput, it has also greatly reduced handling damage.

BENEFITS

As a result of this program, the sensor part count has been reduced from 27 to 12 parts, and 40% of the manufacturing steps have been eliminated. A production rate of 400 units per day has been demonstrated, and 50% unit cost reduction has been achieved. The overall cost avoidance, based on the current projected number of SFW system buys, is estimated to be $140 M.

Another primary benefit of this program is the transfer of technology to other military and commercial applications. OptoElectronics is already implementing the technical accomplishments of this program on the Wide Area Mine (WAM) sensor, an Army antiarmor weapon system.

RESOURCES

Project Engineer: Capt. Tim Kottak
WL/MTEC (513) 255-2461
Contractor: OptoElectronics (a division of Textron)

STATUS

Active
Start Date - February 1989
End Date - December 1991

MANUFACTURING TECHNOLOGY FOR RADAR TRANSMIT / RECEIVE MODULES

CONTRACT NUMBER: F33615-89-C-5705
F33615-89-C-5712

STATEMENT OF NEED

Active element phased array systems utilizing transmit/receive (T/R) modules are considered to be one of the most promising technologies for future ground-based, airborne, and space based radar applications. Benefits include performance improvements and reductions in size and weight. Feasibility and validation T/R microwave modules for many new systems have been built in small prototype quantities or very limited production quantities. Costs are extraordinarily high as a result of complex designs, the need for precision fabrication, the cost of parts and materials, and the general lack of adequate assembly, test and automation equipment. Because of the high cost and quantities required for these modules, program offices are reluctant to commit to an active element phased array design. This program is needed to reduce T/R module costs and demonstrate that the technology is producible.

The objective of this project is to establish and demonstrate a low cost manufacturing capability for large quantities of complex microwave T/R modules for inclusion in active element-phased array radar systems. Affordability and producibility are major concerns and are the primary motivation for this project. Contractors are required to demonstrate high volume producibility at a projected production rate requirement of 1,000 modules per day and a target cost not to exceed $400 per module. This project will support radars efforts for advanced tactical fighter aircraft. Manufacturing processes resulting from this project will be applicable to a continually evolving T/R module specification.

The development of new manufacturing technology for radar T/R modules carries the possibility of more than one successful competing concept. For this reason, two contracts were for a 42-month technical effort. One contract was awarded to Texas Instruments and Westinghouse. The second contract was awarded to Hughes Aircraft.

In addition, efforts are currently underway to transfer this technology to ITT in support of Navy requirements.

APPROACH

An in-place production oriented manufacturing facility for airborne active array T/R modules is highly desired. The primary application of interest is radar systems for advanced fighter aircraft.

Phase I of the program involves definition of the baseline module specification. Phase II defines materials and identifies manufacturing issues related to performance, producibility, and cost and proposes a T/R module configuration that meets the baseline requirements. Phase III produces a module prototype that addresses pertinent design for manufacturability and economic issues. Phase IV establishes the manufacturing processes and controls to demonstrate the production capability for large quantities of low cost T/R modules.

STATUS

Active
Start Date - April1989
End Date - March 1993

BENEFITS

A T/R module which meets the requirements of advanced radar systems requirements will be configured for high volume manufacturing. The module will exhibit the following manufacturing qualities: lower parts count than previous revisions (from 135 to 32 parts); fewer fabrication process steps (from 98 to 20 steps); producibility (will demonstrate a large quantity module build within a 30 calender day period). The module cost will be driven down from $8200 to a projection of less than $400 and the reliability of greater than 125,000 hours Mean Time Between Failure (MTBF) is projected.

RESOURCES

Project Engineer: Michael Marchiando
WL/MTEC (513) 255-2644
Contractor: 1) Texas Instruments/Westinghouse Electric
2) Hughes

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

DEFINITION ANALYSIS AND CONCEPTUAL DESIGN OF AN IMPROVED ELECTRONICS REPAIR CENTER

CONTRACT NUMBER: F33615-83-C-5009

STATEMENT OF NEED

Sacramento Air Logistics Center (SM-ALC) is designated as the Technology Repair Center for all Air Force and selected DoD Ground Communications-Electronics (C-E) Systems and designated airborne and space based communications systems and equipment. As such, it is the single point for overhaul, repair, modification, test, reclamation and rebuild of subassemblies, components and end items of those systems. Advancing technology in microwave, micro-miniaturization, embedded computer systems and micro-processors with built-in-test capability is increasing the capability and importance of C-E systems. It is also driving DoD and the Air Force to a two-level, on equipment and off equipment maintenance concept. The changes in maintenance concept and advances in technology will increase depot workload and the necessity of timely, dependable depot support. The challenge to maintain a cost-effective, productive wartime surge-responsive organic depot maintenance capability in the midst of this "technical revolution" is immense. In performing its mission, SM-ALC is required to maintain and repair electronic equipment that spans forty years of technology. With the introduction of new systems and equipment into the USAF inventory, it is imperative that they modernize to keep pace with rapidly changing technology advances which yield productivity increases while maintaining continued high quality mission support.

The purpose of this program was to conduct a Manufacturing Technology Study for the definition, analysis and conceptual design of an Improved Electronics Repair Center for the Communications-Electronics Division of Sacramento Air Logistics Center (SM-ALC/MAI). The objective was to establish a plan and schedule for improving repair methods, procedures and facilities used by SM-ALC.

APPROACH

The project was divided into the five major tasks described below:

(1) System Environment ("As-Is") Survey - Integrated Computer Aided Manufacturing (ICAM) analytical tools and procedures were used to understand existing methods and procedures within the Communications-Electronics Division and to facilitate the definition of needs.

(2) Workload/Technology Survey - Survey of future workload by systems and the technology level within that system were conducted to identify needs and estimate expected workload.

(3) Needs Analysis Phase - Using the "As-Is" document, Workload/Technology Surveys and the results of on-site interviews/observations, current and future needs within the C-E Division were identified.

(4) Conceptual System Design Phase - The needs identified were converted into projects and requirements that will result in a modernized Electronics Repair Center.

(5) Implementation Plan - An overall implementation plan for selected projects which established a feasible sequence for modernization was produced. The three projects selected were: Integrated Electronics Repair Center, Modernization of Printed Wiring Assembly/Printed Wiring Board (PWA/PWB) Repair/Manufacture, and Improved Software Development.

BENEFITS

Using the "As-Is" Survey, workload survey, technology survey and interviews and observations as sources, the major needs of the SM-ALC/MAI division were identified. It was anticipated that this program would form the framework for short and long term facility and equipment modernization plans within SM-ALC as well as identify future enabling technology programs to further enhance the overhaul and repair capability within AFLC.

STATUS

Complete
Start Date - April 1984
End Date - June 1986
Final Technical Report: AFWAL-TR-86-4093, Volume I-V

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Westinghouse Electric Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

I / J BAND TRAVELING WAVE TUBES FOR THE ADVANCED SELF PROTECTION JAMMER

CONTRACT NUMBER: F33615-79-C-5148

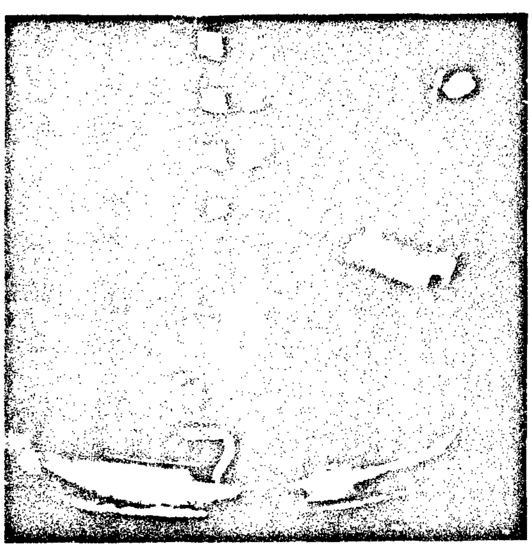
STATEMENT OF NEED

The objectives of this program were to demonstrate reliable tube production, and to reduce costs and complexity of baseline tube designs while retaining performance requirements.

Techniques and objectives established for this program were generically applicable to both continuous wave (CW) and pulse traveling wave tubes (TWTs) developed for military electronic countermeasures (ECM) applications, such as the ALQ-135, ALQ-131, ALQ-126C, ALQ-161, and ALQ-137 systems. Specific tubes selected for this manufacturing project were the high band pulse and CW TWTs for the ALQ-165 Advanced Self Protection Jammer (ASPJ).

APPROACH

There were five phases to this project. The objective of phase I was to build and test pulse and continuous wave I/J band traveling wave tubes using manufacturing modifications to production tubes for comparison/analysis with Computer Aided Design (CAD) predictions. Phase II evaluated the electrical and mechanical tolerance margins of tubes built to the manufacturing modifications required by the analysis of Phase I. Phase III established/verified cost reduction manufacturing process improvements. Phase IV applied cost reduction techniques to pulse and CW traveling wave tubes, and built and evaluated resulting tubes. Phase V demonstrated the unbalanced pilot production line by building five each pulse and CW tubes. One of each tube type underwent life tests. Tubes were then delivered to AN/ALQ-165 countermeasures systems and underwent evaluation.



BENEFITS

Upon completion of an acceptable and manufacturable baseline design for the ASPJ tubes, the results of the manufacturing technology effort were incorporated into modified tube configurations having the following improvements: a) waveguide improvements; b) improved heat sinking; c) less costly helix supports and collectors; and d) repairability improvements for both tubes. These modifications resulted in improved band-edge performance, gain linearity and pushing, lower component temperatures, and reduced material and fabrication costs amounting to $1,364 for each pulse tube and $220 for each CW tube.

During the verification of the cost reduction phase, simplified test methods were established that resulted in a reduction of test time from three and a half hours per tube to an automated test time of one hour, representing a 71 percent reduction. In addition, tubes manufactured during the test showed a 55 to 60 percent yield at an affordable cost that met the ASPJ performance specification. Following a subsequent reliability enhancement program, sufficient data from the test run was obtained to predict a production yield of both tubes in excess of 80 percent in production quantities.

STATUS

Complete
Start Date - September 1979
End Date - December 1987
Final Technical Report: AFWAL-TR-88-4111

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Raytheon Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

IMPROVED ELECTRONIC GUNS

CONTRACT NUMBER: F33615-84-C-5136

STATEMENT OF NEED

The purpose of this program was to provide functional testing of the Lehrer-Pearson, Inc. precision electron gun, and to provide for precision electron gun parts in lower cost traveling wave tubes (TWT) with improved production yield as well as tubes that have improved beam quality.

APPROACH

The following tasks were undertaken as part of this effort.

Task 1: Build two test precision electron guns, one of ceramic, one of quartz.

Task 2: Test two precision electron guns of Task 1 in a beam analyzer. Determine optimum materials.

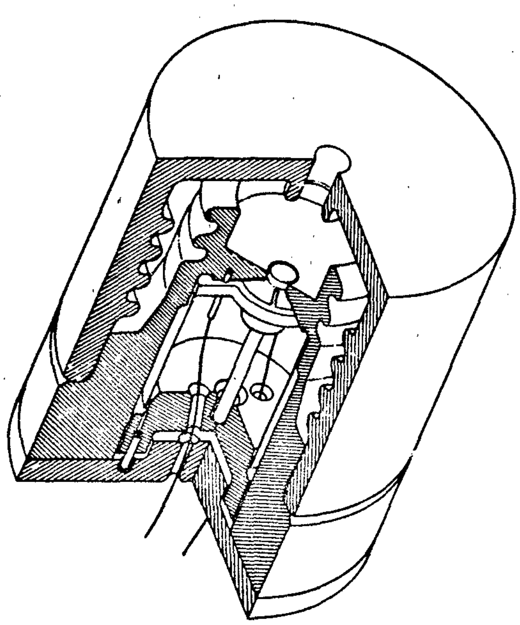
Task 3: Build two more precision electron guns from design selected in Task 2.

Task 4: Build two beam testers to simulate a type 915 HF traveling wave tube.

Task 5: Test two precision electron guns in the two beam testers.

Task 6: Build a type 915 HF traveling wave tube and incorporate precision electron gun.

Task 7: Test the TWT of Task 6 and compare with a TWT employing a conventional electron gun.



BENEFITS

The design concept for the precision electron gun was successfully demonstrated. Assembly could be accomplished in minutes versus hours for a conventional gun. Moreover, the precision gun, if unsealed, could be disassembled in minutes. It should be noted that for an unsealed gun the cathode can be replaced in minutes, requiring only a disassembly of the cathode assembly plus spot welding new electrical leads to the new cathode. Both assembly and disassembly for each gun was accomplished several times. Quick assembly is due to the self-aligning features of the design plus interference fits. Disassembly of the interference fits required differential heating of the mating parts.

STATUS

Complete
Start Date - February 1985
End Date - March 1988
Final Technical Report: AFWAL-TR-88-4134

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Lehrer-Pearson

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR PULSED GaAs IMPATT DIODES

CONTRACT NUMBER: F08635-80-C-0288

STATEMENT OF NEED

The objective of this program was to establish manufacturing methods for large volume, low cost production of double-drift pulsed GaAs IMPATT diodes, which were originally intended for use as the active component in the Advanced Medium Range Air To Air Missile (AMRAAM) transmitter.

The program was carried out in two phases. The initial phase was to establish feasibility and to evaluate material and processing requirements for best yield and reliability. The second phase was designed to establish a production unit to demonstrate a production rate of 300 diodes/month and to implement large wafer processing and automated testing.

APPROACH

The main objectives of Phase I are summarized as follows:

1. Survey diode package designs and suppliers and define package requirements.
2. Finalize specifications for GaAs substrates.
3. Finalize specification for GaAs epitaxial growth.
4. Assess chip fabrication techniques with a view to achieving the best possible reliability and radio frequency performance.
5. Provide information on direct current and radio frequency testing.
6. Provide epitaxial material to for initial device production.

The objectives of the program for Phase II can be summarized as follows:

1. Transfer epitaxial growth and grow large wafers.
2. Transfer process for chip fabrication and process large wafers.
3. Introduce automatic device testing.
4. Introduce automatic wafer probing.
5. Establish 300/month production rate.

BENEFITS

Manufacturing methods suitable for a potential production rate of about 750 diodes per month have been developed. Various novel techniques have been introduced both in wafer processing and in assembly which have enabled these rates to be achieved. The diode specification of 22 Watts of peak output power has been easily met with average yields of about 60% of devices exceeding 27W output. Output levels of >45 Watts have been seen. Device reliability has been improved by the adoption of new metallization methods and these results justified by burn-in tests. These tests have also suggested that a more sophisticated burn-in technique can be used to remove potential diode failures in a shorter time than the present method. Epitaxial growth of complex p and n-type GaAs layers has been demonstrated on wafers up to 3" in diameter and wafer yields of about 30% to a difficult specification have been accomplished. Average unit cost of $207 for > 27W output devices and $124 for devices of > 22W output have been achieved. Further cost reduction due to increased throughput is small due to the high speed of the processes already conducted.

STATUS

Complete
Start Date - October 1981
End Date - April 1983
Final Technical Report: AFWAL-TR-83-4132

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Raytheon Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MILLIMETER WAVE IMPATT DIODES

CONTRACT NUMBER: F33615-84-C-5022

STATEMENT OF NEED

The objective of the program was to establish a high yield, low cost manufacturing process for silicon millimeter-wave IMPATT diodes, specifically W-band pulsed diodes for radar systems and V-band continuous wave operation diodes for communication equipment.

APPROACH

This program was accomplished in two phases. Phase I (18 months) evaluated and optimized material growth, diode fabrication, packaging, and testing technique for high volume, low cost impatt diodes for w-band millimeter wave seekers and v-band satellite communication transmitters. Phase II (12 months) implemented the Phase I improvements in a production environment and demonstrated that these advanced techniques would support the diode production rates needed for the intended applications.

To establish a high-yield, low cost manufactuirng process for these silicon millimeter-wave IMPATT diodes, the contractor identified six specific manufacturing operations that needed to be improved during Phase I of this program. These six operations are as follows:

1. IMPATT diode material manufacturing: Establish a rapid evaluation method, increase substrate size from 1.5 inch to 2.0 inch diameter.
2. IMPATT diode processing (wafer fabrication): Implement methods to fabricate diodes that have the same active areas throughout a manufacturing lot.
3. IMPATT diode packaging: Accomodate new techniques to handle and inspect the small piece-parts.
4. Trim etch and DC screening: Establish a combined semi-automatic trim etch and DC screening method.
5. Diode evaluation: Demonstrate the viability of a large-signal RF impedance measurement technique.
6. Reliability test: Establish projections for the reliability of the V-band CW and the W-band pulse diodes.

During Phase II, the contractor demonstrated the manufacturing improvements developed during Phase I by establishing a pilot production line. Phase II tasks were thus:

1. Producibility Demonstration: This included technology verification and pilot line establishment.
2. Program Benefit Tracking.

BENEFITS

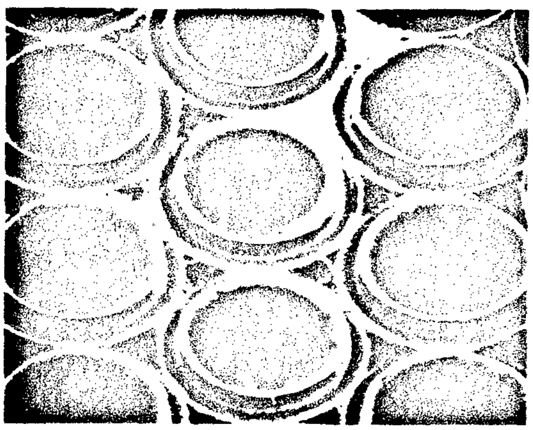
Program benefits included a 300% yield and reproducibility improvement in diode material, improved chip uniformity, and a 10 times saving in diode package trim etching labor. Additionally, the cost of IMPATT diodes has been reduced by 50% from \$1500 to \$750. For high volume (more than 100,000 units), the cost will be approximately \$90.

STATUS

Complete
Start Date - April 1983
End Date - November 1987
Final Technical Report: AFWAL-TR-87-4123

RESOURCES

Project Engineer: David McLaine
WL/MTEC (513) 255-2461
Contractor: Hughes Aircraft Company



TEMPERATURE COMPENSATED MAGNETS

CONTRACT NUMBER: F33615-78-C-5013

STATEMENT OF NEED

The magnetization of rare earth-cobalt magnets decreases with time, particularly at or after exposure to elevated temperatures. Also, the magnetization decreases (and then increases) nearly reversibly upon heating (and subsequent cooling). Both these factors mean that the magnetic flux in the air gap of a device changes both with temperature and time. This necessitates frequent and costly calibration of traveling wave tubes, gyros, and accelerometers. The life cycle of devices and acquisition costs are of major importance for any application. Several million dollars are spent by the Air Force each year for maintaining Air Force inertial systems. Thus it is essential that process improvements or modifications be made to produce thermally stable high quality and temperature compensated magnets to accomodate device design and functional requirements.

The basic goal of this program is to establish manufacturing methods for the production of samarium-cobalt magnets that have been selectively alloyed for intrinsic temperature compensation and processed to eliminate factors that are responsible for a wide variation in magnetic properties and time related instabilities.

APPROACH

The program was divided into four phases: Pilot Line Plan, Pilot Line Construction, Process Optimization, and Process Validation. The four basic problems addressed were: (1) low oxygen processing to improve time and temperature related stabilities as well as to achieve higher energy product; (2) improved crystal alignment and reduced cold work; (3) intrinsic temperature compensation with heavy rare earth substitution of samarium to achieve a reversible temperature coefficient to suit device design and functional requirements, and (4) precision testing using accelerometer as a test device.

BENEFITS

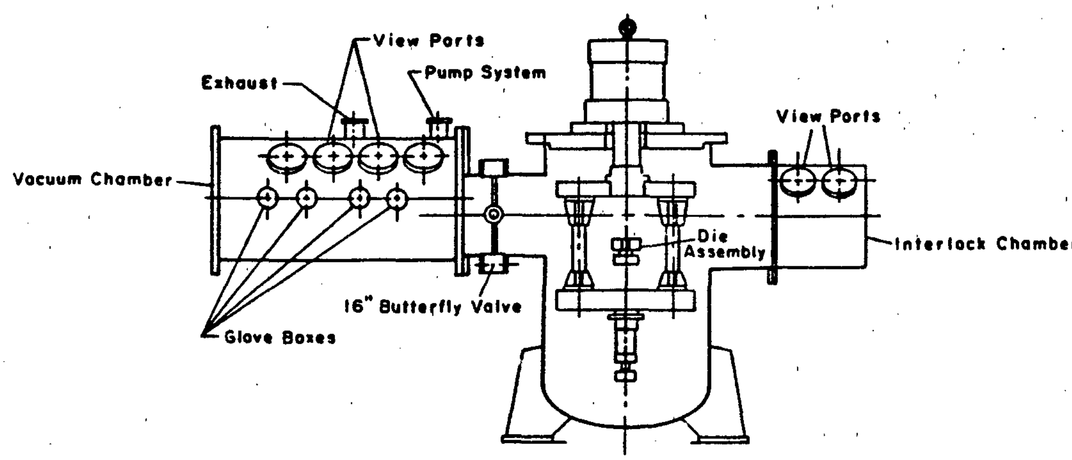
The techniques developed have a potential for producing higher energy product in the other rare earth alloy systems. Benefits of this program include: low oxygen processing procedure development, improved orientation, cold work minimization, and intrinsic temperature compensation.

STATUS

Complete
Start Date - May 1978
End Date - August 1984
Final Technical Report: AFWAL-TR-84-4092

RESOURCES

Project Engineer: David McLaine
WL/MTE (513) 255-4621
Contractor: Crucible Steel Corporation



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

BUBBLE MEMORY FOR PERIPHERAL ELECTRONICS

CONTRACT NUMBER: F33615-87-C-5215

STATEMENT OF NEED

For satellite and space system applications a reliable, nonvolatile, radiation-hardened compact memory is needed that is capable of storing 2 to 3 million words of data. The size, weight, and power of this memory must be minimal and the long term reliability must be exceptional.

The objective of this three-phase project is to establish a manufacturing capability for the electronic circuits required to implement a radiation hardened mass storage (large memory capacity) system configured with bubble memory devices as the storage media. Circuit functions will be partitioned into a radiation-hardened monolithic or hybrid device compatible with known or selected rad hard manufacturing process.

Bubble memory exists for both avionics and missile systems and represen^ a storage media which can meet these requirements and is a step forward from the militarized magnetic tape recorders presently utilized. These memory devices are non-volatile and have been demonstrated to be hard to all types of radiation. However, the support chips for these parts are not hard to radiation, which prevents the implementation of a hardened large capacity memory. No radiation hardened circuits are available with sufficient complexity to allow a 4 megabit bubble memory module to operate.

The objective of this three-phase project was to establish a manufactruing capability for the electronic circuits required to implement a radiation hardened mass storage (large memory capacity) system configured with bubble memory devices as the storage media. Circuit fuctions were partitioned into a radiation-hardened monolithic or hybrid device compatible with known or selected rad hard manufacturing process.

APPROACH

In Phase I a target memory system descriptive specification was completed which included a top-level memory module design description specification and requirements. Design, breadboarding, preliminary package lay-out, and simulation of the pre-driver and sense amplifier hybrid circuits were also accomplished. In addition, the design and specification were completed for the error detection and correction (EDAC) first-in/first-out (FIFO) monolithic Application-Specific Integrated Circuit (ASIC).

Phase II, "Manufacturing Process Validation," emphasized schematic capture of the EDAC/FIFO ASIC , preparation of final layouts of the pre-driver and sense amplifier hybrid circuits, preliminary device fabrication and testing.

Phase III demonstrated two areas: 1) the module manufacturing process by fabrication of the chips and components and 2) the assembly of several mass storage bubble memory demonstration units.

BENEFITS

Nuclear environment studies showed that more than 99% of the radiation in space is due to X-rays, hence shielding will be effective.

STATUS

Complete
Start Date - December 1985
End Date -September 1991
Final Technical Report in progress

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Science Applications International Corporation

COMPLEMENTARY METAL OXIDE SUBSTRATE (CMOS)/ SILICON-ON-SAPPHIRE (SOS) READ ONLY MEMORY (ROM)

CONTRACT NUMBER: F33615-82-C-5110

STATEMENT OF NEED

Microelectronic devices must meet military system designers specifications for mission life, reliability, performance data requirements, and minimum radiation levels. Memory chips make up the largest single item in a processor. With the demand for more "on-board" processing, users require more memory. Therefore, memory devices have significant impact on the cost and reliability of any system. The objective of this effort is to establish a manufacturing capability for the volume production of specialized silicon gate CMOS ROM circuits that are capable of meeting the reliability and medium radiation environment for military systems.

APPROACH

The Random Access Memory (RAM) activity pursued under this contract had an objective of generating a 16K RAM capable of withstanding 10K to 50K Rad (Si). The contract called for the manufacturing development of sample devices for the purposes of evaluating techniques to be used in the 16K RAM. Manufacturing samples of a 4K RAM, fabricated in 2 micron SOS technology, were tested and delivered.

In addition to the 4K Manufacturing Technology samples, the preliminary design of a 16K 2 micron RAM was begun under the basic contract.

The second aspect of this program was the manufacturing development of a 32K ROM. This effort called for the fabrication of manufacturing samples of the 32K ROM. The option emphasized the manufacturing characterization of the device with less emphasis upon manufacturing layout. This was possible because a 32K ROM design had previously been sponsored by the Air Force with Tracor Corporation in Austin, Texas. The acquisition of the ROM manufacturing layout from Tracor through subcontract allowed Rockwell to proceed directly to manufacturing fabrication and evaluation. Ultimately, 100 manufacturing samples of the 32K ROM were delivered in accordance with contract requirements. In addition, 50 process follower samples were also delivered.

BENEFITS

This program successfully established the manufacturing capability for radiation-hardened 32K CMOS/SOS ROM devices, the Silicon-on-Sapphire (SOS-3) manufacturing process and SOS material wafer requirements. A nonrecurring cost savings in the generation of these devices of approximately $250,000 was realized as well as a continuing 5 to 10 percent cost savings due to yield improvement. Also, a subsequent generation of 32K ROMs were generated for the Small ICBM program. This separate activity resulted in the successful delivery of two configurations of ROMs to the Small Missile program in June 1987.

STATUS

Complete
Start date - August 1982
End date - November 1989
Final Technical Report: AFWAL-TR-88-4216

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Rockwell International Corporation

MANUFACTURING TECHNOLOGY FOR MICROPROCESSOR SUPPORT CIRCUITS

CONTRACT NUMBER: F33615-80-C-5127

STATEMENT OF NEED

The objective of this program is to establish manufacturing processes and controls necessary for high yield production of specialized silicon gate CMOS/SOS (complementary metal oxide semiconductor integrated circuits/silicon-on-sapphire substrates) microprocessor support circuits that are capable of meeting the reliability and radiation dose requirements for military applications.

APPROACH

The scope of this effort on silicon-gate CMOS/SOS large scale integrated (LSI) support circuits encompassed the following work areas:

1. Definition and verification of any interaction between design rules and manufacturing process controls with respect to radiation performance of LSI devices.
2. Definition, implementation and verification of those production process controls required to meet MIL-M-38510 high reliability specification for future line certification.
3. Definition, implementation and verification of production process controls required to maintain acceptable performance of production line devices at total dose levels of 50,000 rads on a lot-by-lot basis.
4. Full device characterization and parameter correlation of the performance of devices produced with the modified process controls developed on this program with respect to MIL-M-38510 and radiation environments, as verification of the effectiveness of the improved production processes.

The test vehicles used for this program were microprocessor support circuits which in that time-frame represented timely building blocks for use in military microprocessor applications. This included an 8-bit GPU, a 4Kx1 Static RAM, a memory driver circuit capable of driving the large capacitance associated with bus operations, and finally a 16-bit DGPU which represented a logical progression from the original 8-bit GPU.

BENEFITS

This program has made three major contributions to the military electronic needs of the Air Force. First, the establishment of a SOS manufacturing process with radiation-hard capability has matured so that now radiation levels of 500K rad are possible. Consequently, the Small ICBM program is based upon single-layer metal SOS technology. Second, the 4K RAM developed as an example part of this program has subsequently been used directly in several military programs, the most noteworthy of which is the MILSTAR program. Third, the SOS-4 radiation-hardening program and the RAM programs have been brought forward to where both 16K RAMs and 32K ROMs were available for the Small ICBM program. These devices withstand radiation doses at the 500K rad level. In addition, this radiation-hard process has sufficient gamma-dot capability that state retention cells with transient capability exceeding 10^{11} rads per second are available. Several Small ICBM circuits, which require state-retention through high transient levels have been fabricated in the SOS process.

STATUS

Complete
Start Date - October 1980
End Date - August 1988
Final Technical Report: AFWAL-TR-89-8008

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM(513) 255-2461
Contractor: Rockwell International Corporation

MANUFACTURING TECHNOLOGY FOR RAD HARD CMOS MICROPROCESSOR CHIP SET

CONTRACT NUMBER: F33615-85-C-5012

STATEMENT OF NEED

The data requirements for large numbers of operations per second and the sophistication of new sensor systems which collect data continuously are increasing rapidly. The requirement for high density circuitry for logic and memory functions is most times diametrically opposite to that for increased radiation hardness. Advanced space systems require both high speed data processing and high levels of radiation hardness. Commercial integrated circuits are designed for high speed and high functional density with no consideration for radiation hardness. For military applications, the design and device processes have to be compatible to satisfy system requirements for high speed operation plus radiation hardness.

APPROACH

This project will provide the capability for multiple source enhanced, radiation-hardened Complementary Metal Oxide Semiconductor (CMOS) microprocessor circuits from a common dual technology database to be extracted from vendor-specific mask tapes. This will enable either bulk CMOS and CMOS/Silicon-on-Sapphire (SOS) vendors to be used for the same design. This technology is being demonstrated by implementing Tracor's advanced microprocessor chip set design in bulk CMOS with Harris Semiconductor and CMOS/SOS with Marconi Electronic Devices, Inc. In verifying the interrelationships between the common database and either manufacturing process, the 32K Read-Only-Memory (ROM) devices were fabricated by the subcontractors. Device characterization is in progress.

In summary and to date, a Radiation-Hardened Cell Library (3-4 micron geometries in single-level metal interconnects) were established and verified. Manufacturing layouts (3-4 micron geometries) for the 32K ROM, Double Address Select Unit (DASU), Quad Bus Interface Unit (QBIU) are completed. The manufacturing fabrication and verification of the DASU and 32K ROM devices are also complete. A Radiation Hardened Cell Library (2 micron geometries and double level metal interconnects) applicable to both CMOS/SOS and CMOS Bulk S has been established. Manufacturing layouts utilizing the 2 Micron Cell Library were applied to the Quad Interrupt Control Timer (QICT), Math Accelerator Unit (MAU), and the Microprocessor Control Unit (MCU).

BENEFITS

The demonstration of the manufacturability of this chip set will increase the availability and reduce the risk of implementing the high speed radiation hardened devices into advanced satellite systems. This program will provide a parts technology capable of implementing a computer which operates at greater than one million operations per second. The devices in the chip set will be able to satisfy minimum radiation requirements of ten to the fifth power RAD SI for memory devices and 5 times ten to the fifth power RAD SI for random logic devices. They will have increased data processing capability, and will lower design and acquisition cost due to the technology alternatives.

STATUS

Complete
Start Date - May 1985
End Date - February 1990
Final Technical Report in progress.

RESOURCES

Project Engineer: Eugene Miller
WL/MTEM (513) 255-2461
Contractor: Tracor Aerospace

MANUFACTURING TECHNOLOGY FOR RUGGED THIN GaAs SOLAR CELLS

CONTRACT NUMBER: F33615-88-C-5415

STATEMENT OF NEED

Present silicon solar cell technology is limited to a beginning-of-life (BOL) power of 20 W/kg for a rigid panel and a mission life of less than five years. Future DoD missions will require BOL power for flexible area panels approaching 300 W/kg for lifetimes greater than five years.

A recent program proved that GaAs solar cell technology can meet the future DoD mission requirements, but the use of GaAs as a viable power source was hindered by its cost and higher weight. This program used the metal organic chemical vapor deposition (MOCVD) growth method to meet the program objectives. The MOCVD equipment produced 90 (2cm x 4cm) solar cells in one run, which demonstrated high production throughput.

The objective of this GaAs program is to establish cost effective techniques to manufacture large quantities of highly efficient, lightweight, radiation resistant space qualified gallium arsenide solar cells. The specific goal of the program is to establish production techniques and demonstrate a 50% yield of space qualified solar cells.

APPROACH

The approach to achieve this objective will be MOCVD of GaAs on germanium substrates, which will be thinned to reduce the overall cell weight. This program is designed to demonstrate the production of these cells and to extend the technology to 4cm x 4cm and 6cm x 6cm large area cells. The survivability of these cells is enhanced through development of welded solar cell interconnect technology, which can withstand the higher temperatures associated with the absorption of energy from laser and nuclear weapon exposure in addition to reducing the mass of the contacts for higher thermal-cycle life. This cell interconnect and mounting technology will be demonstrated through fabrication of four panels of one square foot each subjected to performance and thermal-cycling life. This GaAs/Ge solar cell technology is the prime candidate for several satellite power systems requiring a range of survivability, including the Follow-On Early Warning System (FEWS) and the Strategic Defense Initiative Organization (SDIO) Survivable Power (SUPER) demonstration.

BENEFITS

These cells have many improved performance features over presently available silicon solar cells for application on Air Force and Department of Defense satellite vehicles. At operating conditions, these cells will produce 20 to 30 percent more power at beginning of life (BOL) and exhibit less degradation from particulate radiation from the trapped radiation belts in low and intermediate earth orbits. In addition, the rugged germanium substrate makes it possible to reduce the thickness and weight of these cells and provides a more robust cell to minimize the damaging effects of thermal and mechanical strain from exposures to laser and nuclear weapons attacks. This ruggedness, combined with the high temperature contact capability, make this cell a prime candidate for survivable solar cell arrays. Since the cells show less degradation with temperature, they will provide more power than conventional silicon cells in a survivable array configuration. These cells represent a new generation of minimum area-- that is, lightweight-- solar cell arrays for military and commercial satellite applications.

STATUS

Active
Start Date - September 1988
End Date -April 1992

RESOURCES

Project Engineer: Wallace C. Patterson
WL/MTEC (513) 255-2461
Contractor: Applied Solar Energy Corporation

ELECTRONICS

SOLID STATE MICROWAVE SYSTEMS (SSMS)

CONTRACT NUMBER: F33615-85-C-5064

STATEMENT OF NEED

The research and development of gallium arsenide discrete and monolithic ir. grated circuit devices is progressing rapidly. Utilization of this technology for electronic warfare, communications and radar applications are being supported by all of the services. High volume, low cost production has not been addressed and will limit the rate of implementation. For example, the cost of a complex microwave transmit/receive module for airborne active elements, phased array radar is, in small quantities, over $7500. Reducing this cost at least 10-fold will be required before such systems are feasible. Also, since 1500 to 2000 modules will be required per radar, the ability to manufacture large quantities of modules is a major concern.

The objective of this program is to establish the manufacturing technologies needed to cost effectively manufacture large quantities of gallium arsenide(GaAs) discrete and monolithic integrated circuit devices and modules which have potential application in Air Force systems.

APPROACH

The project team, headed by Westinghouse, included three system houses, a leading device manufacturer, a materials supplier and a specialist in polishing materials characterization. In addition to Westinghouse the contractor team included TRW, Rockwell, Avantek, Johnson-Matthey (formerly Cominco), Varian, and Aracor. This contractor team fabricated twelve different microwave device types which included power, gain, low noise, and diode devices with application to radar, electronic warfare (EW), and communication systems. These devices were fabricated on five different types of GaAs semiinsulating material using ion implantation techniques. During the program, devices were fabricated on approximately 1000 three inch GaAs wafers, and the devices' electrical characteristics and yields analyzed. Comparisons between the results for the five material types were made. The devices fabricated were incorporated into radar, EW, and communication modules. The modules have also been tested.

In addition to the device and module fabrication efforts the Westinghouse team has placed significant emphasis on the wafer preparation and materials and device characterization aspects of monolithic microwave integrated circuit (MMIC) fabrication. Wafer sawing and polishing methods were evaluated. These efforts resulted in an improved polishing technique for GaAs wafer which significantly reduces the surface and subsurface damage observed in the substrate material. This polishing technique has been transferred to Johnson-Matthey, and the details of the technique are available for industry application. Nondestructive evaluation of the starting and processed wafers were studied in detail.

The contractors have evaluated the following techniques and recommend them for application by the industry: contactless mobility, photon backscattering, electron channeling, EL_2 mapping and photocurrent mapping.

In addition, the contractors have further developed on-wafer RF testing, frame-tape mounting and use of test element groups for evaluation of fabricated devices. All of the data collected for this program is available in a computerized database established at Westinghouse.

BENEFITS

Contractors have established on-wafer power RF testing, frame-tape mounting, and the use of test element groups (TEG) for evaluation of fabricated devices. The RF on-wafer testing significantly decreased the time and cost involved in the electronic testing oı devices. The automatic test replaces the manual and sometimes destructive test method, therefore increasing die-to-wafer yield. The frame-tape mounting facilitated the rapid testing of diced components at TRW, where on-wafer testing was not available. Over the life of the program, the FET yield improved 5 to 23 percent. The two-step polishing technique established during the program reduced the wafer surface damage index by a factor of 10.

STATUS

Complete
Start Date - December 1985
End Date - December 1990
Final Technical Report in progress.

RESOURCES

Project Engineer: Wallace Patterson
WL/MTEC (513) 255-2461
Contractor: Westinghouse Electronic Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ADVANCED DISPENSER CATHODES

CONTRACT NUMBER: F33615-84-C-5012

STATEMENT OF NEED

The need for improving Type M dispenser cathode processing became apparent during the Space Systems Division's (SSDs) development of K-band generic traveling wave tubes (TWTs).

The objective of this project is to improve and control manufacturing processes employed in the fabrication and overspatter of Type M dispenser cathodes. The application of the manufacturing technology results will be in the next generation of communication satellites. Obtaining predictable TWTs with a ten year operating life is a necessity for this application.

APPROACH

The approach is to increase the life of the dispenser cathode employed in the space TWTs by manufacturing a more uniform and consistent electron emitting surface. Control of the tungsten and the barium-calcium-aluminate materials along with control of the impregnation process will contribute to more repeatable cathode performance.

In Phase I the process parameters and the physical aspects of the tungsten billet materials were characterized to ensure reproducibility. Sintering temperatures and times for each material, as well as density, gas permeability, and surface area for each billet were tracked for optimization purposes. The raw materials and processing methods of the barium-calcium-aluminate materials were evaluated to optimize the manufacturability and behavior of the materials. Parameters that influence the cathode impregnation process in the furnace are time-temperature profiles, atmosphere conditions, and total mass of material. These parameters were optimized to ensure a uniformly consistent composition in the cathode. Sputter coating of the tungsten cathode surface also was evaluated and optimized to yield a standard product. Optimum particle size, shape, and purity were determined in Phase II.

BENEFITS

Control of the tungsten and the barium-calcium-aluminate materials along with control of the impregnation process will contribute to more repeatable cathode performance.

STATUS

Complete
Start Date - October 1984
End Date - June 1990
Final Technical Report in progress.

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: Semicon Associates, Inc.

ELECTRONICS

MANUFACTURING TECHNOLOGY FOR HgCdTe FOCAL PLANE ARRAYS

CONTRACT NUMBER: F33615-86-C-5006

STATEMENT OF NEED

Mercury cadmium telluride is considered by DoD to be one of the most promising materials for infrared (IR) detector arrays for strategic and tactical sensors used for surveillance, missile guidance and night observation. It has a high quantum efficiency and can be tailored for peak response at specific spectral bands through the selection and control of stoichiometry. Arrays of 64 x 64 or more detectors have been fabricated in several laboratories, but yields and production rates are low. At present the understanding of electrical and photoelectrical properties of HgCdTe detectors as related to material properties, defects, and the interfaces between the HgCdTe and the CdTe substrates is still being investigated. These uncertainties coupled with the lack of production experience and the difficulty of handling the fragile material result in low yields and production rates.

The objective of this program is to increase yields and improve production rates.

APPROACH

To accomplish this effort, the project addresses the infrared detector fabrication processes, characterization methods, and testing procedures. Manufacturing processes are being automated and computer controlled to reduce manual labor and to increase throughput and yield. Data analysis and testing are directed at optimizing the many complex manufacturing processes.

The projects are structured around two major milestones: 1) producing and characterizing detector arrays from starting materials and 2) documenting the resulting yield, cost, and throughput. The first task established a baseline from which progress can be measured. This program was funded by SDIO.

BENEFITS

- Increased production yields of HgCdTe detection arrays
- Improved production rates
- Reduced acquisition costs

STATUS

Active
Start Date - January 1987
End Date - December 1991

RESOURCES

Project Engineer : Michael Price
WL/MTEC (513) 255-2461
Contractor: Hughes Santa Barbara Research Center

MANUFACTURING TECHNOLOGY FOR HIGH VOLTAGE POWER SUPPLIES

CONTRACT NUMBER: F33615-89-C-5704

STATEMENT OF NEED

High Voltage Power Supplies (HVPS) are a critical part of many weapons systems. The applications include display, communication, radar, Electonic Counter Measures, and associated transmitter equipment aboard the B-1, B-52, F-111, F-15, F-16, E-3, E-4,ground support test equipment, and other military systems. For this program HVPS are defined as thlose with output voltage in the range of 270 volts to tens of kilovolts. This category of power supply has been identified by the Air Force Program Office's as a critical component for which producibility and reliability need to be enhanced. During full scale development efforts, it is frequently the HVPS which dictates whether an electronic system is delivered on schedule. Even after a system is operational, the reliability of the HVPS can continue to be a problem. Weapon system program office personnel indicate and field failure confirm that power supplies are a high replacement item. This is especially true of HVPS that are used with traveling wave tubes (TWTs).

The objective of this effort is to improve the quality of components and materials used in the fabrication of high voltage power supplies (HVPS) and to optimize and improve the manufacturing processes used in fabrication and testing.

APPROACH

HVPS for three types of airborne weapons systems, electonic countermeasures (ECM), radar, and communications (with space vehicles) are included in the program. For each type of power supply, this effort will characterize and optimize three major areas--materials, components, and manufacturing processes-- and will be followed by the fabrication of several HVPS to demonstrate a manufacturing capability for selected Air Force weapon systems.

The HVPS program is divided into four phases. In Phase I the contractor will characterize and optimize the entire range of materials, components, and manufacturing processes used in the fabrication of HVPS for airborne ECM, radar, and communication applications. In Phases II,II, and IV the contractor will fabricate three of each airborne weapon systems HVPS ECM (Phase II), Radar (Phase III), and Communications (Phase IV) as vehicles to validate the manufacturing and reliability enhancements established through the efforts of Phase I. The device will meet the performance specifications of a HVPS currently installed in an operational system or of a HVPS designed for integration into a system under development. The contractor will select the designs for the HVPS to be built as validation devices.

BENEFITS

The results of this effort will enable manufacturers to produce HVPS, which are more reliable and maintainable at a lower unit cost.

STATUS

Active
Start Date - January 1989
End Date - December 1994

RESOURCES

Project Engineer: Michael Price
WL/MTEC (513) 255-2461
Contractor: Northrop Corpration

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ELECTRONICS

FEATURE RECOGNITION FOR PRODUCT DEFINITION USING KNOWLEDGE BASED SYSTEM

CONTRACT NUMBER: F33615-87-C-5264

STATEMENT OF NEED

The development of computer aided design (CAD) systems has led to a new revolution in which there is a demand by designers to transfer existing engineering drawings and aperture cards into a CAD data base for analysis. This requirement has produced a number of computer vision systems which are used to scan the drawings in order to produce image data. Such systems, invariably, produce only geometric data bases and a few attributes at best. In the manufacturing environment, however, such geometry must be interpreted into meaningful terms for the various production functions, such as process planning and control. Therefore, there is the need to go beyond geometric recognition for a part that needs to be manufactured.

APPROACH

This project utilizes the advantages of Initial Graphics Exchange Specification (IGES), the results of Product Data Definition Interface (PDDI), and the capabilities of the modern scanners to develop a Knowledge-Based System to recognize features on turned parts from the image derived from an engineering drawing. The system may be envisaged to be receiving scanned data and outputting a list of form-features with the attributes necessary for manufacturing. The specific objectives were as follows:

- To investigate the capabilities and effectiveness of scanner technology in the feature recognition process
- To develop algorithms to recognize the features of turned parts from its image data obtained by scanning an engineering drawing
- To test the algorithms and demonstrate the feature recognition process for a variety of turned parts
- To determine the effects of center-lines, dimension lines, and text in the feature

BENEFITS

A form feature recognition system has been developed and successfully tested. The system converts a digitized engineering drawing of rotational parts with only external features into an ordered feature list. The input to the system is an IGES file. All the textual and dimension information are ignored by the system. It is realized that that the basic building blocks are the shape recognition. The feature recognition process relates these shapes with manufacturing implications. Fifteen geometric shapes have been identified using the recognition system. Twenty four external form features have been successfully recognized and 41 external features have been identified. The remaining features can be recognized by upgrading the templates and increasing the knowledge-base.

STATUS

Complete
Start Date - July 1987
End Date - January 1989
Final Technical Report: WRDC-TR-89-8053

RESOURCES

Project Engineer: Troy Strouth
WL/MTEM (513) 255-2461
Contractor: North Carolina A&T State University

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR THERMAL BATTERY PRODUCTION

CONTRACT NUMBER: F33615-84-C-5064

STATEMENT OF NEED

Thermal batteries are nonrechargeable electrochemical energy sources, employing salt electrolytes which are solid and nonconducting at ambient temperatures. Upon ignition of an integral pyrotechnic heat source, the salt electrolyte melts and becomes conductive, allowing the battery to supply electrical energy to external electrical loads.

The lack of battery standardization, due to system-specific requirements, has discouraged improvements to production/testing which would be more economically feasible for large volume production runs. However, the electrical requirements for modern "Smart" weapons systems, combined with the need for extended shelf life has now lead to the increased use of thermal batteries. Present and projected usage of thermal batteries has reached the point where modest cost improvements will result in substantial system savings.

The objective of this effort is to establish reliable, low cost manufacturing methods with quality assurance/quality control procedures for thermal batteries. This program addresses specific aspects for the assembly and testing of these batteries.

APPROACH

The contractor conducted a critical review of battery construction parameters and benefits appraisal of thermal batteries. After the review, the contractor implemented a process for manufacturing the batteries. Then, the contractor validated HT manufacturing technology and the nondestructive evaluation processes developed and implemented earlier in the program.

Phase I identified eight areas in battery construction where there were potential benefits to be derived from advanced manufacturing techniques: (1) real time X-ray system and an associated X-ray focal length study; (2) programmable non-destructive tester; (3) pellet press filling simulator; (4) pellet weight and sort machine; (5) pellet stacking machine; (6) electrode fabrication system; (7) welder guidance system; and (8) an increased capacity destructive tester.

Phase II pursued the development of improved processes for those areas identified in phase I. Historically, reliability assurance has resulted from thorough destructive testing throughout the production run. This program established generic and economical manufacturing methods, quality assurance procedures, and nondestructive/destructive tests for the production of thermal batteries.

BENEFITS

Manufacturing and inspection improvements are projected to reduce the cost of the thermal battery by approximately 20 percent.

STATUS

Complete
Start Date - September 1984
End Date - November 1991

RESOURCES

Project Engineer : Troy Strouth
WL/MTEM (513) 255-2461
Contractor: Eagle Picher Industries, Inc.

INTEGRATED DESIGN SUPPORT (IDS)

CONTRACT NUMBER: F33615-84-C-0060
F33615-87-C-3251

STATEMENT OF NEED

Massive amounts of today's technical data resides on paper or in electroinic databases accessible only from specific computers. This makes the management, sharing and configuration control of this critical information difficult, time consuming and expensive. The emergence of highly complex weapon systems, such as the B-1 and F-22, will only compound this problem in the future. Extremely large investments in current design and information systems makes it economically infeasible to start over. A strategic, evolutionary approach, coupling incremental advancements in technology and standards with cultural and organizational change, is the only viable solution. The Manufacturing Technology Directorate and the Armstrong Laboratory Human Resource Directorate (AL/HRG) have joined forces on the Integrated Design Support (IDS) system. IDS is an Advanced Development effort funded by Program Element 63106F, Logistics Research.

The objectives of this program are to define the requirements for managing and sharing technical engineering data digitally in the logistics environments, and to develop and demonstrate a feasibility prototype responding to these requirements.

APPROACH

The first goal of the program is to define the exact critical set of technical data required to support a weapon system throughout its life cycle. The result of this effort is the Product Data Control Model (PDCM), and IDEF1X entity relationship data model. The PDCM has been extensively reviewed by both government and industry, and the program maintains a leadership role within the Product Data Exchange Specification (PDES), another emerging Computer Aided Aquisition and Logistics Support (CALS) standard using Standard for The Exchange of Product Data (STEP). The PDCM contains over 800 entities and represents the most comprehensive information model for a generic weapon system life cycle in existence.

A second goal, which complements the first goal, is to define the specifications for an information system that can effectively manage the massive and complex model defined by the PDCM. In IDS, this is referred to as the Integrated Resource Control System (IRCS), which is a data dictionary or repository that holds the PDCM as the enterprise conceptual schema and provides the mappings among external, conceptual, and internal schemas. The IRCS also is the main integrating component in a distributed, heterogeneous computing environment. IDS participates in the (NIST) Integrated Resource Directory System Committee (IRDS), another emerging CALS standard. The IRCS is envisioned to be a fully active, three-schema repository that supports ad hoc query and dynamic schema mapping. This effort formed the basis for a prototype of a joint Air Force Systems Command/Air Force Logistics Command demonstration at Oklahoma City Air Logistics Center (OC-ALC).

BENEFITS

The Integrated Design Support System demonstrations established a strong link between the R&D and user communities, offering significant benefits to both. The demonstrations provided AFSC with an opportunity to showcase and evaluate key technologies, and improve the understanding of the ALC environment. AFLC gained extensive training on information integration, and experience in how these technologies can be applied to their specific problems. The demonstration also led directly to the establishment of an Information Integration Testbed at OC-ALC, to be supported by both AFSC and AFLC. Additionally, a recommendation resulted for a joint AFSC/AFLC Working Group to structure the roadmap for incrementally moving the ALCs toward the CALS vision. Continuing "teamwork" philosophy will ensure that both parties, developer and user, will receive the maximum return on investment, increasing weapon system readiness and reducing maintenance costs.

STATUS

Phase I: Completed September 1990
Phase II: Active, End Date April 1992
Final Technical Report AFHRL-TR-89-6,
Volumes I-V

RESOURCES

Project Engineer: Jeff Ashcom
WL/MTIA (513) 255-7371
Contractor: Rockwell International
Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

INTEGRATION TECHNOLOGY

PDES APPLICATION PROTOCOL SUITE FOR COMPOSITES (PAS-C)

CONTRACT NUMBER: F33615-91-C-5713

STATEMENT OF NEED

The need to support systems such as the B-2 and the F-22 creates an imposing burden on the Air Logistics Centers (ALCs) (and also prime and subcontractor) existing capability to accept, manipulate, transfer, and share digital product data. In the few cases where the Air Force transfers data the methods are labor intensive and often use outmoded, yet technology is readily available. Often, if so much as a software version is changed, the ALCs must completely redesign their data exchange techniques. The PAS-C program will provide a neutral and unambiguous data exchange technique that will improve the data management capability within the aircraft structural composites component community.

The objective of this project is to develop and demonstrate a product definition information model sufficient to represent and exchange information to design, analyze, test, produce, assure the quality of, and repair composite parts as typified by aircraft composite structural components. The Air Force has a growing volume of aircraft composite structural components entering into the inventory. This project will initiate and establish the procedures required to provide a neutral data format for composite structure so that the composite product data can be digitally transferred between industry producers and also between these producers and government agencies. This resulting neutral format is intended to support Integrated Product Development (Concurrent Engineering) principles, reduce product delivery time, and reduce the cost of Air Force weapon systems. The results of this project will help establish the costs, benefits, and risks of using this neutral format.

APPROACH

The program is composed of three phases and will focus on the product class typified by composite airframe structural components. The product data required to design, analyze, test, produce, and assure the quality of these components will form the basis of this program. Production requirements are measured by the completeness of the data to fully satisfy the requirements of Level 3 production drawing packages as specified in MIL-T-31000.

Maintenance and disposition of composite components will not be a primary focus addressed in the program. The program will not directly address the manufacture of composite fibers, tapes or plies, though the product data required to define them for use in the manufacture of parts is addressed in the program.

RESOURCES

Project Engineer: John Barnes
WL/MTIB (513) 255-7371
Contractor: South Carolina Research Authority

BENEFITS

The results of this project will help establish the costs, benefits, and risks of using this neutral format. This project is also intended to define the framework for application specification implementation procedures to be used in making the Product Data Exchange using STEP (PDES) specification supportive of the full spectrum of manufactured parts and procedures throughout the product life-cycle. PAS-C will promote the growth and maturation of PDES and endorse its use as a national standard.

STATUS

Active
Start Date - July 1991
End Date - October 1995

SPARE PART PRODUCTION & REPROCUREMENT SUPPORT SYSTEM (SPARES)

CONTRACT NUMBER: F33615-90-C-5002

STATEMENT OF NEED

The re-procurement of spare parts continues to be expensive. The Computer-Aided Acquisition and Logistics Support (CALS) initiative has identified spare parts procurement to be one of the top four areas of emphasis. A large portion of the cost of spare parts procurement can be attributed to the manufacturing data content. This manufacturing data content is driven by the need for human understanding and effective utilization of paper engineering drawings, and the multitude of parts lists and military specifications which accompany these drawings. In general, paper drawings are difficult to keep current, difficult to read, and are usually inaccurate because of changes to the parts that have not been incorporated into the drawings. In addition, the correlation and interpretation of the essential Mil-Specs with the drawings is also a time consuming and expensive task. The manufacturing operations within Logistics Command rarely use digital product data. When digital product data is generated, no process exists for the retention and management of that data. There is a need to have efficient two-way communication of product data between the Air Logistic Center (ALC) data repository and the manufacturing facilities. Also, manufacturing specific data, such as numerical control (NC) tapes, needs to be stored and cross referenced for ease of use and reuse.

APPROACH

The approach is to create digital models and utilize application software to facilitate the definition of the spare parts procurement package. It will begin by working closely with ALCs to select a representative set of high cost items that are frequently procured and to analyze the process and the paperwork that must be completed to procure these parts. The contractor will then analyze the ways that digital product models could be created either from existing computer aided design files or by digitizing paper drawings or otherwise establishing a digital representation of the actual part. The next step will be to design the digital product models and use the prototype software that would demonstrate the concepts. ALC participation, guidance, and acceptance is an integral part of this effort. ALC implementation funding is an essential element of the long range application of these concepts.

BENEFITS

The benefits include assistance to ALC personnel in the preparation of spare parts procurement packages. Data and drawing interpretation will be more effective and accurate through the use of computer support.

For newly designed or redesigned parts, drawings will not be necessary. For the vendors that must supply the re-procured parts, the net result will be an easier, quicker, more accurate understanding of the manufacturing requirements for the part being procured. For the implementation sites, the benefit will be a drastic reduction in work order time through major reductions in processing times associated with data input, numerical control programming, and fixture/tool design. The final result will be a more accurate parts definition conveyed to the manufacturer (whether internal or external) resulting in quality improvement, readiness enhancement, and extensive cost savings to the government through the reduction of excessive engineering and manufacturing preparation time.

STATUS

Active
Start Date - December 1990
End Date - April 1995

RESOURCES

Project Engineer: John Barnes
WL/MTIB (513) 255-7371
Contractor: General Atomics

INTEGRATION TECHNOLOGY

UNIFIED LIFE CYCLE ENGINEERING, PHASE II (ULCE)

CONTRACT NUMBER: F33615-89-C-5707

STATEMENT OF NEED

Studies conducted by industry associations and government agencies over the past decade have identified that decisions made early in the design of a weapon system or equipment have a significant, often adverse effect on readiness and supportability. Recent demands for more sophisticated performance have increased system design complexity. At the same time projected battle turn-around times have decreased, causing readiness and supportability to become even more critical issues.

The objective of this program is to develop and implement a query optimizer and view update processor for Unified Life Cycle Engineering (ULCE) mechanical engineering design. These technologies will be incorporated into heterogeneous distributed database query products to improve their performance and expand their capabilities.

The program planning will take maximum advantage of related government and industry initiatives and products and identify for development those ULCE essential procedures that are not yet available -- for example, supportabilty models and design decision aids.

APPROACH

Incorporate knowledge-based query optimization algorithm and view update processor (resolution of conflicts) into both relational and object-oriented database domains.

STATUS

Active
Start Date - September 1989
End Date - January 1992

RESOURCES

Project Engineer: Brench Boden
WL/MTIB (513) 255-7371
Contractor: Softwell Associated, Inc.

BENEFITS

The ULCE program will provide design aiding tools for use by both industry for designing and the government for design checking/optimizing, design specification preparation, proposal evaluation, reprocurement, and in-house manufacturing. These activities will be deliberately designed for modularity and availability to permit cost effective application by small contractors as well as large ones. This will result in considerable improvement in weapon system acquisition, development time and cost. It will also provide significant increase in readiness and warfighting capability because the total design and manufacturing community will be fully capable of designing right the first time. The system will be sufficiently modular to enable it to effectively incorporate emerging design aids as technology progresses.

ASSEMBLY SYSTEMS IMPLEMENTATION (ASI)

CONTRACT NUMBER: F33657-81-C-2108

STATEMENT OF NEED

The Assembly Systems Implementation (ASI) program addresses hidden costs and technology voids within the current manufacturing processes such as: out of position work; inability of contractors to meet schedules; inefficient resource utilization; high rate of scrap and re-work; proliferation of engineering and manufacturing change orders; inefficient change management; and the dependency on expediting.

Development and implentation of computer integrated manufacturing (CIM) concepts is embodied in this program. Together with Douglas Aircraft Company, MANTECH is moving forward in the design, development, and implementation of CIM concepts to achieve reductions in above-the-shop-floor production costs in the assembly of C-17 transport aircraft.

APPROACH

ASI will provide a shared data resource, user-machine system to support the operations, management, analysis, and decision-making functions in the factory. These modules are being designed to accommodate a manual, semiautomatic, and automatic process. This program is a joint project between the C-17 system program office and MT as an industrial modernization incentive program (IMIP).

BENEFITS

The Assembly System Implementation (ASI) project is an above-the-shop-floor data development and control system. It should be considered a significant tool in implementing a "paperless factory", therefore providing both tangible and intangible labor savings.

With funding of $7 million, the program is expected to have a $ 34 million payoff in reduced costs. Specifically, opportunities for improvement include reduction of tooling and inventory, improvement of communications among systems, optimization of people/machines, and use of feedback to monitor processes and to detect potential problems.

STATUS

Active
Start Date - May 1989
End Date - December 1993

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: Douglas Aircraft Company

DEPOT DIGITAL DATA INTEGRATION (DDDI)

CONTRACT NUMBER: F09603-90-G-0012-0038
PRAM Office

STATEMENT OF NEED

Warner-Robins Air Logistics Center's (WR-ALC) computer-aided design/computer-aided manufacturing (CAD/CAM) environment, engineering and manufacturing functions are not digitally integrated. When engineering is required to develop an engineering modification to an existing part, a paper drawing is requested from EDCARS (Engineering Data Computer-Assisted Retrieval System). The engineer must then create a 3-dimensional (3D) CAD model from scratch. Upon completion of the modification, a paper drawing revision is produced and scanned back into EDCARS for future use. When manufacturing receives a work order for that part, the drawing is again requested from EDCARS. The manufacturing engineer must re-create another 3-D model from which numeric control (NC) programming is developed. Loft data required to support both engineering and manufacturing functions must be manually obtained and interpreted from hardcopy loft data books.

WR-ALC is also experiencing a problem with first article quality for procured F-15 tubing. They are unsure if the problem is caused by the quality of the data they are providing to vendors, or by the quality of the vendors' manufacturing process.

The objective of this program is to improve the quality and producability of the WR-ALC engineering and manufacturing processes through the development and implementation of tailored, standards-based applications of advanced information and manufacturing technologies.

APPROACH

Through the application of advanced information and manufacturing technologies, the F-15 DDDI program will provide immediate access to McDonnell Aircraft Company's (McAir) digital loft and tubing databases. The integration of WR-ALC's CAD/CAM systems will provide the capability to share technical information created within the WR-ALC enterprise. The F-15 DDDI program will be implemented using the WR-ALC's existing CAD/CAM hardware and software. McAir's digital loft and tubing databases will be ported to WR-ALC's VAX system. This program is a joint effort between ASD/AEM, (the productivity, reliability, availability, and maintainability office) and MT.

BENEFITS

This program will support R & M 2000 objectives of increasing war fighting capabilities, decreasing manpower requirements, and decreasing operations and support (O & S) costs due to: 1) Reduced manual engineering and manufacturing effort; 2) Improved quality and timeliness of the product definition data necessary to internally or externally manufacture parts; 3) Reduced engineering and manufacturing cycle times through rapid user access to digital technical information; and 4) Use of existing WR-ALC CAD/CAM equipment.

The program also provides a model for future development of specific, tailored applications of Computer-Aided Acquisition and Logistics Support (CALS) technologies to improve supportability and reduce life-cycle costs for existing weapon systems.

STATUS

Active
Start Date - June 1991
End Date - June 1992

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: McDonnell Douglas Aircraft Company
PRAM Office Engineer: Mr. Doug Black
ASD/AEME (513) 255-7993

INTEGRATED PRODUCT PROCESSING INITIATIVE (IPPI)

CONTRACT NUMBER: N/A

STATEMENT OF NEED

The Integrated Product Processing Initiative (IPPI) recognizes the need to bridge the gap between design and manufacturing. A large technology void exists in the transfer of neutral product information between these two domains (design and manufacturing) and autonomously generated intermediate part representations are required for efficient processing.

The objective of the IPPI program is to implement a complete product information thread utilizing PDES/STEP information models at all product-based workstations between CAD and manufacturing workstations. A second objective of the IPPI program is to utilize lessons learned in an actual production environment to provide guidance for current and future program activities. Additional objectives of IPPI are to incentivize follow-on commercial products, support open systems architectures, and promote the development and utilization of standards.

APPROACH

Since the focus of IPPI is to provide adequate support for production operational manufacturing, rotational parts will be selected to permit concentration on extending the scope of PDES utilization throughout manufacturing. The IPPI program emphasis will be on implementing a full product data driven production operation and developing "lessons learned". Therefore, a simpler technical task will be selected in favor of addressing the broader scope of implementation.

BENEFITS

Closer integration between design and manufacturing resulting in reduced lead time and improved accuracy/flexibility by driving PDES into actual manufacturing applications. This provides a missing link in integrating design and manufacturing, supporting overall Framework and Open Architecture efforts, establishing internal product data research capability, and linking with national PDES Testbeds.

RESOURCES

Project Engineer: 1st Lt. Mary Gomez
WL/MTIB (513) 255-7371
Contractor: To Be Determined

STATUS

New Start
Planned Award Date - June 1992

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ENTERPRISE INTEGRATION PROGRAM (EIP)

CONTRACT NUMBER: F33615-90-C-5001

STATEMENT OF NEED

The integration and effective use of information in manufacturing and all across the weapons system procurement life cycle has been identified as a high priority problem area that must be resolved. Current manufacturing information systems are structured in such a way as to inhibit the implementation of upgrades or new systems due to lead time, effort, cost and scheduling required for design changes. Also, the architectures and tools for the implementation do not support quality design.

The objectives of EIP are to 1) establish a national framework for information integration and facilitate the development of a national consensus concerning the nature of the framework, 2) implement a broad spectrum of commercial products based on standards and compliant with the national framework, 3) research and develop advanced technologies to fill critical technology voids, and 4) ensure technology insertion and exploitation on a national scale. To accomplish these objectives, the EIP framework will be based on open systems concepts and will support national and international standards.

APPROACH

Based on the framework for enterprise integration, the EIP will package and implement, in at least three near-term environments, commercially viable, technically supported and maintained integrated information systems supporting the data and information requirements of end-users, developers, and management. The framework developed in Phase I of the program, the enterprise integration reference model, will provide the backbone of enterprise integration. The framework will: 1) support the cost-effective management, reuse, and exchange of information and tools across the product life cycle, 2) function in a distributed heterogeneous environment, 3) allow for multiple interoperable implementations from different vendors, 4) provide a migration path from legacy systems, 5) provide for the future evolution of technology and processes, and 6) support the automation and enforcement of an individual organization's policies and procedures.

The enterprise integration reference model will identify and define the necessary functions and services, the internal and external boundary interfaces between the functional modules and the external products, and the applicable standards required to achieve enterprise integration through an open-systems concept rather than vendor proprietary architectures. The enterprise integration reference model will allow for interoperability and interchangeability of framework compliant products developed by multiple vendors.

Two types of products, which must be compliant with the framework reference model, are envisioned-internal and external framework products. Internal products are those products which are necessary to achieve the functionality of the enterprise integration framework. External products are those to which the enterprise integration framework must link. There can be many implementations of the framework reference model; each organization will be able to trade-off performance, quality, and features of different vendors' framework-compliant products. As the individual technology components mature, organizations can upgrade their products when and if it is economically feasible, while still being able to integrate with the remainder of their framework products.

The implementation segment of the EIP requires production capability in at least three pilot application sites. The selection of implementation sites and applications will be determined by the prime contractor and the pilot sites. Three different types of applications are required to demonstrate the wide applicability of the framework and integration technology, to build markets for the framework-compliant products, and to provide incentives for the framework technology vendors.

BENEFITS

This project will attack the major changes which need to be made in the management of information throughout an enterprise. The project will also point out how to achieve significantly improved ways of procuring the information required to describe weapon systems. New improved hardware and software systems may be purchased and readily incorporated into the factor environment. The resultant savings could amount to hundreds of millions of dollars.

STATUS

Active
Start Date - April 1991
End Date - May 1996

RESOURCES

Project Engineer: 1st Lt. Todd Guss
WL/MTIA (513) 255-7371
Contractor: SofTech, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

AUTOMATED AIRFRAME ASSEMBLY PROGRAM (AAAP)

CONTRACT NUMBER: F33615-87-C-5217

STATEMENT OF NEED

The airframe industry has had some success in automating discrete manufacturing functions, but cannot fully realize the cost benefits associated with automation without fully integrating the production environment. Studies have shown roughly half of the cost of an airframe is due to the huge amount of paper documentation required for design, manufacturing and process planning, assembly instructions, tooling layouts, schedules and quality assurance.

The Automated Airframe Assembly Program is the first of an extended series of activities which will attack the major cost and quality drivers in airframe assembly modeling and shop floor operations. The major product will be prototype software for assembly modeling, tooling, quality assurance, and assembly planning and scheduling.

APPROACH

This was a two-phased effort to provide the technology foundation and experience base required for implementing an Automated Airframe Assembly Center (AAAC) in the mid to late 1990's. Phase I, Needs and Requirements Definition, was awarded in 1986 to three industrial teams led by Northrop Aircraft Division, Douglas Aircraft Company, and General Dynamics. Phase I identified the long-range needs and requirements of achieving an AAAC, and explored alternate strategies to capitalize on the project technology development through the 1990's.

It also identified the needs and requirements and developed the conceptual design for a near term assembly system implementation. Northrop was awarded the phase II contract and worked closely with the following subcontractors to complete the work: Control Data Corporation, ONTEK Corporation, Oracle Corporation, Price Waterhouse, Simgraphics Engineering Corporation, ICAD Corp., Martin Marietta, Hewlett-Packard, Intellicorp and Savoir.

AAAP concentrated upon enhancing a manufacturer's ability to design an airframe, plan and describe its assembly, and schedule resources to accomplish assembly. These processes involve the creation and management of diverse types of information, knowledge of how to apply that information, and the ability to share the information throughout the manufacturing environment.

In the Advanced Technology Development phase of the program (phase II), team members developed and demonstrated high-risk, high-payoff technologies that provide the means by which information can be efficiently created and universally shared.

The capabilities developed under the program directly address the major obstacles encountered in achieving an integrated, information-driven, manufacturing enterprise. Some examples of technologies developed include:

- Assembly Modeling
- Communication Technology
- Generative Assembly Planning
- Dynamic Shop Floor Scheduling
- Feature-Based Modeling

BENEFITS

The AAAP has effectively combined and applied existing technology to network communications; has created new approaches to designing, planning, scheduling and controlling airframe assembly; and has demonstrated fundamental improvements in the ability to share information between diverse data systems. Each of these advancements can contribute to reducing costs, improving quality and shortening the cycle time of the design, assembly and support of complex aircraft.

STATUS

Complete
Start Date - November 1983
End Date - July 1991
Final Technical Report in progress

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: Northrop Corporation

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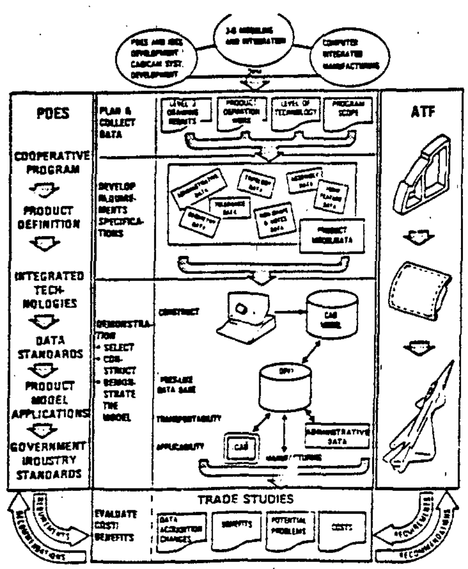
DIGITAL PRODUCT MODEL FOR THE ADVANCED TACTICAL FIGHTER (ATF)

CONTRACT NUMBER: F33657-86-C-2085
F33657-86-C-2087

STATEMENT OF NEED

There is no effective means of communicating digital part descriptions (geometry, material, assembly, tolerences and administrative data) between different aerospace companies and DoD organizations or often within individual organizations. Current means of data exchange are inefficient and do not permit automated transfer to other applications which can use the data. Human intervention is required to interpret existing data and convert it into a computer readable format for specific applications, a cumbersome and error prone means of communication.

The digital product model project, using the Advanced Tactical Fighter (ATF) as a target, was an aggressive effort by ManTech, the SPO and contractor teams to begin overcoming these problems.The intent of this project is to demonstrate the potential for the use of digital product models in place of the paper engineering drawings that are currently required for delivery of system product data.



APPROACH

The ATF contracotr teams, working closely with ManTech, SPO, and Sacramento Air Logistics Center personnel, defined the feasibility and requirements of moving to digital product models. They analyzed the information content of production (Level 3) drawings, it's user, and the capability of existing and emerging standards to accomodate their requirements in a neutral way.

The results were used in building digital product models of representative ATF components which were successfully transferred between team member sites and applied to several design and manufacturing processes.

BENEFITS

Digital product data was exchanged among ATF team members and the Air Logistic Center to drive existing automated CAD/CAM applications. This project clearly demonstrated the ability of DPM technology to be a fully functional replacement for reprocurement drawings and support automated systems requirements for data exchange. The results also contributed to advancing digital product data exchange standards and technology.

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: 1) Lockheed Corporation
2) Northrop Corporation

STATUS

Complete
Start Date - October 1987
End Date - October 1990

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

FLEXIBLE ASSEMBLY SUBSYSTEM

CONTRACT NUMBER: F33615-84-C-5137
F33615-84-C-5048

STATEMENT OF NEED

The aerospace manufacturing environment is generally characterized as very low-volume, batch-manufacturing. As a result, operations tend to be very labor intensive and have low productivity. The fabrication trends over the past years have been toward closer tolerances, more difficult-to-drill materials, and higher complexity, all of which contribute to lower productivity. Assembly alone accounts for almost half of the direct labor costs for all fabrication operations, four times more than for any other single operation. The aerospace manufacturing problem is further compounded by a trend toward small lot-size procurement.

A standard approach toward reducing assembly cost involves decreasing the quantity of detail parts through the substitution of machined parts or, in the case of advanced composite structures, integrally cured complex structures. However, there is a practical limit to the impact of these approaches. Ultimately all structures must be interfaced with skins, clips, ribs, doors, longerons, etc., to permit joining to the next higher level assembly. These requirements force the need for assembly operations on all airframes, including those of the new generation represented by the F-22. An assembly operations assessment has projected that neither near-term or future assembly costs can be expected to fall below 35 to 40% of the airframe labor cost without a significant advancement of shop-floor manufacturing technologies.

Resolution of the above problems required the design/development of a revolutionary, flexible robotic assembly system embedding numerous advanced state-of-the-art technologies. Integration of the shop-floor processing system with the engineering product definition database and manufacturing management system was essential.

APPROACH

The program, awarded to Grumman Aerospace Corporation, was performed in two phases. Phase I included research and development of conceptual designs, and feasibility demonstrations required to establish the key technologies which are critical for achieving flexible automated assembly systems in the future.

In 1989 Grumman was awarded a contract follow-on for pilot production, funded by Air Force ManTech, F-16 IMIP, and Navy ManTech. The purpose of the pilot production is to bridge the gap between feasibility demonstration and production implementation, to position technology for large scale implementation, and to achieve reduced product cost and improved quality.

BENEFITS

Under the pilot production effort, the FAS cell has been integrated into Grumman's overall factory business/technical management system. EA-6B components contracted to be built by Grumman were designed using guidelines defined by the cell's capabilities, were assembled on the cell, and are currently in use on in-flight systems. Due to the success of the pilot production effort, Grumman has taken the initiative to incorporate the FAS cell in their strategic planning. Current design for the automation efforts targeted for production on the cell are projected to yield 56% direct labor savings, and Grumann has used the cell's capability to bid an assembly contract at a 30% price reduction.

STATUS

Active
Start Date - July 1983
End Date - December 1991

RESOURCES

Contractor: Grumman Aerospace Corporation
Project Engineer: 1st. Lt. Robert Stauffer
WL/MTIB (513) 255-7371

INTELLIGENT TASK AUTOMATION

CONTRACT NUMBERS: F33615-82-C-5092
F33615-82-C-5139

STATEMENT OF NEED

Current robots have a limited ability to sense their environment and require the objects which they manipulate to be located with extreme accuracy. This entails the use of hard tooling and time consuming programming. For economically automating production of items which have a high number of configurations (i.e., military microswitches), or have very low volumes (i.e., airframe parts), the production system must be flexible and be able to accommodate a variety of different assembly tasks with a minimum of hard tooling and programming time. Additionally, these systems must be able to adapt, in real time, to part-to-part dimensional variability and unstructured part positioning.

The objective of this program is to develop and demonstrate generic technologies which: (1) form the basis for advanced intelligent task automation systems; (2) have near term application to unit processes, component assembly, and many aspects of defense batch manufacturing; and (3) establish the technology base which will open up many new opportunities to apply intelligent systems to complex military tasks. To verify the ability to integrate the technologies, a microswitch was robotically assembled from the component parts scattered on tray.

APPROACH

The technical approach is twofold. First, multiple source development of the needed technology (sensors, microprocessors, mechanical design, language development, adaptive learning, real time controls, etc.) necessary for the realization of proposed subsystem feasibility demonstration was conducted. Second, the subsystem was assembled from the individual components and the technology was integrated.

Demonstration was conducted to prove both system applicability to defense manufacturing and flexibility to other military applications. This project designed and developed the sensing and control technology required for robotically performing complex assembly tasks for microswitches in an unstructured environment.

STATUS

Complete
Start Date - September 1982
End Date - June 1990
Final Technical Reports: AFWAL-TR-86-4122, Volumes I- III
WRDC-TR-89-8020
AFWAL-TR-85-4062, Volumes I-III

BENEFITS

ITA demonstrated the plausibility of automating the tasking, process planning and control of robotic systems with the introduction of AI techniques into robotic programming. The use of automation throughout the manufacturing process is highly desirable to take advantage of the accuracy, repeatability and reliability of the current geneation of manufacturing robots and devices.

Since the initial ITA prototype demonstration, the intelligent software technologies and AI techniques have been migrated to several other application where the technology is being validated against manufacturing goals representing different environment. Developments in vision sensing technologies were migrated to the Flexible Assembly Subsystems Program (FAS), robotics simulations techniques were further developed under the Automated Airframe Assembly Program (AAAP), and advances in machine control technology were utilized in the platform for the Next Generation Controller Program (NGC).

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: 1) Honeywell, Inc.
2) Martin Marietta Corporation

NEXT GENERATION WORKSTATION / MACHINE CONTROLLER (NGC)

CONTRACT NUMBER: F33615-89-C-5706

STATEMENT OF NEED

Economic competitiveness is one of the most crucial issues facing this country today. Improving the manufacturing capability of the United States to compete in world markets has risen to the top of strategic plans for most manufacturing executives and government officials. A survey of 217 top manufacturing executives identified that a Next Generation Controller would be required to fully attain strategic manufacturing capability. In response to the President's domestic action plan, the dwindling market share of American control manufacturers and the need for domestic manufacturing for advanced controls, this program is being undertaken. By retaining a strong advanced control industry, the prospect of economic competitiveness for this country's manufacturing will improve by avoiding technological dependancy and second class manufacturing operations.

The objective of the Next Generation Workstation/Machine Controller program is to develop and validate a specification for an Open System Architecture Standard for process controllers.

APPROACH

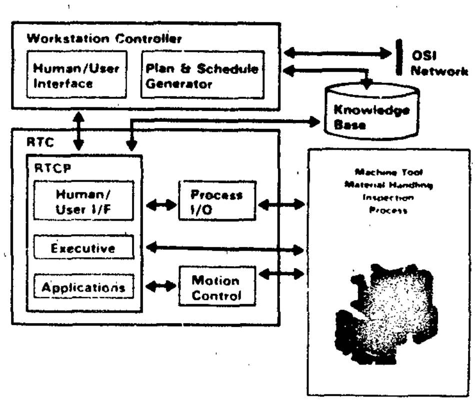
The Next Generation Controller (NGC) will be comprised of a number of physical and logical subsystems and modules interconnected by standard(izable) interfaces. The modules may be assembled in a variety of configurations to provide control systems for a wide range of machines and workstations. The next generation machine/workstation controller architecture will support a wide range of processing and discrete part manufacturing applications including machine tools of all types, robots, electronic assembly, material handling devices, inspection devices, and virtually all types of automated equipment, in both manned/unmanned and network/stand-alone environments.

The NGC will provide control of a manufacturing workstation and the subsystems therein. The NGC control architecture is not to address higher levels of manufacturing systems (i.e., cell, center, factory level control). A workstation consists of a single material transforming device and related supporting equipment (i.e., material handling or inspection, with sufficient information processing and control to permit autonomous response to commands). Typical NGC control architecture might include motion control, process input/output, process control interface, machinery, workstation controller, knowledge-base, human/user interface, and the communications system.

Commercially competitive Low End Controller (LEC) prototypes are being developed to be followed by rapid market introduction to assist in the recovery of the domestic controller industry.

BENEFITS

Significant reductions in the development and implementation costs for advanced computer control systems.



STATUS

Active
Start Date - September 1989
End Date - August 1993

RESOURCES

Project Engineer: Michael Hitchcock
WL/MTIB (513) 255-7371
Contractor: Martin Marietta Corporation

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INTEGRATION TECHOLOGY

ADVANCED DECISION SUPPORT FOR SCHEDULING (ADSS)

CONTRACT NUMBER: F33615-84-C-5093

STATEMENT OF NEED

The objectives of this project were to establish a set of automated tools to assist in the long range planning and scheduling required to install and operate a manufacturing system to produce and ship new aerospace products; demonstrate the ability to transport manufacturing planning and control strategies/systems utilized to improve the productivity of sheet metal fabrication into other work centers; demonstration of a strategy for implementing application systems in an integrated environment; and establish an Engineering Change Control System utilizing automated tools for determining effectivity as well as sophisticated configuration control strategies required by the aerospace industry.

The overall objective of the ADSS program was to identify candidate tools for decision support in the application of control, planning, and scheduling in the aerospace manufacturing environment.

APPROACH

The approach consisted of three separate but intertwined strategies. These strategies were:

1. The formulation of a coalition of representative users.
2. The identification of specific software.
3. The establishment of the technical effort to meet the goals and objectives of the project.

The Coalition Support included the Aerospace Manufacturing Advisory Board (AMAB) which was made up of thirteen (13) aerospace companies. This board participated in defining industry needs and critiqued the documented solutions that were produced. The Integration Management Board (IMB) was the primary vehicle for preparation and evaluation of the integration and implementation plans. Additionally, the IMB coordinated the timing and performance requirements of the common solutions and scenarios developed under this project.

The second strategy was to utilize the existing Integrated Computer-Aided Manufacturing (ICAM) software products to be integrated into the overall ADSS solution. These software products included the Integrated Information Support System, the Production Planning and Control System, and the Manufacturing Control Material Management System.

The third strategy was to utilize the ICAM System Development Methodology (SDM) to define the problems, design solutions, build prototypes, and demonstrate the integration of the ADSS solution. SDM is a systematic controlled approach to accomplishing the ICAM Life Cycle.

BENEFITS

The results of the Advanced Decision Support for Scheduling program were cost improvements in the preplanning stages, early identification of tooling and resources requirements, rapid response to change, reduced work-in-process inventory levels, reduced inventory, and better material yields.

STATUS

Complete
Start Date - July 1984
End Date - March 1988
Final Technical Report: AFWAL-TR-88-4126, Volumes I-XIV

RESOURCES

Project Engineer: David Judson
WL/MTI (513) 255-7371
Contractor: Boeing Company

DATA AUTOMATION PROCESSOR (DAPro)

CONTRACT NUMBER: F33600-87-C-0464

STATEMENT OF NEED

Control Data Corporation, Boeing Military Airplane Corporation, Structured Dynamics Research Corporation, and General Electric Company, building on previous work, have developed an automated transparent software solution for administering policies and procedures, managing data, and supporting end users in a distributed heterogeneous computing network environment. The automated transparent software solution, called the Integrated Information Support System (IISS), implements Department of Defense Computer-Aided Acquisition and Logistics Support (CALS), American National Standard Institute, and Open Systems Interconnection Standards in a flexible and evolvable architecture.

The IISS philosophy of "knowledge bridging" ensures seamless evolution of systems from legacy to new technologies, business systems, and enterprise practices. The IISS system architecture integrates four domains: technology communications, network management, data administration, and user interface management. The IISS system implements management specified policy and procedures and also provides management with "real" options for mixing hardware, software, vendors, and implementation schedules.

The IISS effort has supported the development of new industry and government standards and has maintained the currency of over 40 standards embodied in the IISS architecture. The IISS project delivered the DoD IDEF1X modeling standard, support technologies, and training for several thousand government and industry engineers and technicians. Today over 50 businesses, including Fortune 500 companies and small businesses, offer IISS system components and services that originated from this project.

The DAPro objective, under the prime contractor Control Data Corporation, was to establish, operate, and enhance a Test Bed. This project provided technical and educational support for Integrated Information Support System users representing several manufacturing technology centers and disciplines, including integration technology, sheet metal, machinery, composites, electronics and assembly. Each center could be supported by the Test Bed, which included system development, test, production emulation, and technology transfer environments.

APPROACH

From 1983 through 1989, several nonproprietary prototype versions of Integrated Information Support System (IISS) technologies were installed in support of Industrial Modernization Improvement Projects (IMIP), CALS Expo '88 and '89, the Sacramento Air Logistics Center, the Wright Laboratory Materials Directorate and Manufacturing Technology Directorate, the F-22 System Program Office, and the National Institute of Standards and Technology.

STATUS

Complete
Start Date - January 1987
End Date - September 1990
Final Technical Report: WRDC-TR-90-8007, Volumes I-VIII

BENEFITS

For each of the three multimillion dollar IISS projects [Boeing - Integrated Sheet Metal Center (ISMC), G.D.-Advanced Machining System (AMS), and McAir-Integrated Composite Center (ICC)], major aerospace contractors reported a 33 percent savings. Concepts, components, and tools were identified and analyzed formally using an extensive cost benefit model.

The savings for overall IISS system development, installation, and operation was 33 percent. Three elements of the software life cycle were measured and showed a savings of 23 percent for development, 48 percent for maintenance, and 28 percent for cost avoidance.

RESOURCES

Project Engineer: David Judson
WL/MTI (513) 255-7371
Contractor: Control Data Corporation

INTEGRATION TECHOLOGY

ENGINEERING INFORMATION SYSTEM (EIS)

CONTRACT NUMBER: F33615-87-C-1401

STATEMENT OF NEED

There is no global framework with which to manage tools, data and the design process in the Very High Speed Integrated Circuits (VHSIC) design environment. Areas of concern include: complexity of engineering increasing; many engineers working in parallel on a design project; no vendor supplies complete spectrum of CAD/CAE tools -- users develop additional tools in-house; tools have different user interfaces requiring extensive training for each new tool; tools use proprietary data models and formats; and tools run on dissimilar hardware/software platforms.

The Engineering Information System (EIS) project was established to improve the process for integrating, managing and using engineering information and support tools. Major objectives are the development of a set of acceptable candidate standards for computer-aided engineering, the demonstration of the functionality and the utility of the candidate standards, and the support for their adoption as industry standards.

APPROACH

The EIS program was multi-year funded under the 6.3A Very High Speed Integrated Circuit (VHSIC) program line in WRDC/EL.

The VHSIC EIS effort was organized into a sequence of incremental developments over a three year period. Each incremental development was evaluated by potential users and, if favorably reviewed, transitioned to the user community. This user feedback was essential to the success of the EIS effort and was actively solicited. The first phase of the program was to develop a set of candidate standards and specifications. The second phase was to build a prototype system which implemented those specifications. The third phase was to demonstrate the utility of the specifications in a VHSIC design environment.

The EIS team did not specify a particular design for EIS or adopt a layered approach to organizing candidate standards. Each layer consisted of a set of interfaces that hid the layer below. In this way, reference architecture, domain independent services, and application specific services was specified so that implementation of a selected layer were not dependent on the implementation of the layer below. This arrangement allowed each vendor the greatest possible flexibility in building EIS conformant products.

BENEFITS

- Provide a technical foundation for a cost effective method for integrating new and existing computer assisted engineering tools and data bases
- Support the management, reuse, and exchange of engineering information
- Provide consistency across different tools' user interfaces
- Encourage the portability of engineering tools
- Be adaptable to future engineering methods
- Be extendible to other domains
- Provide an easy upgrade path for existing systems
- Work in a distributed, heterogeneous environment.

STATUS

Active
Start Date - September 1987
End Date - September 1991

RESOURCES

Project Engineer: Daniel Lewallen
WL/MTIA (513) 255-7371
Contractor: Honeywell, Inc.

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NATURAL LANGUAGE INTERFACE / DISTRIBUTED HETEROGENEOUS ENVIRONMENT

CONTRACT NUMBER: F33615-89-C-5734

STATEMENT OF NEED

The use of Natural Language Processing (NLP) offers several advantages over keyword systems, the current state of the art in full text retrieval. One of these is improvement in precision (the percentage of retrieved texts that are applicable) and recall (the percentage of the applicable texts that are recalled). Most of us have observed this difficulty with the keyword system by using the on-line card catalogue at libraries. The difficulty arises because of a number of problems: 1) the same words can produce different meanings (i.e., "juvenile victims of crime" vs "victims of juvenile crime" would not be distinguished by a proximity search); 2) different words can produce the same meaning (i.e., "postprandial abdominal discomfort" would not be recalled by the keywords "stomach pain after eating"); and 3) the domain can affect the meaning (i.e., "floating" in the context of swimming is rather different than in the context of banking).

The objective of this program was to determine the usefulness of a natural language approach to ad hoc query in a distributed heterogeneous environment.

APPROACH

The purpose of this work was to transition successful NLP research into applications, rather than to conduct basic research. To do so successfully required improvements in portability and robustness over current NLP technology. Portability was demonstrated across machines, across domains and across applications in Phase I.

Robustness was achieved by using a phrase parser tolerant of ungrammatical, unknown and ill-formed input. This was achieved by compromising constraints required for full text understanding, and instead, achieving a level of partial understanding sufficient for productive text retrieval.

BENEFITS

Demonstrations of a NLP based full text retrieval system applicable to large scale text databases called "TextPro" were made that show significant potential for the application of NLP. The major new developments demonstrated were new methods in achieving robustness and portability of NLP technology applied to free running text. The program explored other applications of NLP including the application of a Natural Language Interface (NLI) to distributed information systems. Example applications of "TextPro" are 1) to make on-line technical orders maintained by the Air Force Logistics Command more effective to users by providing access, browsing and retrieval of appropriate text using simple English queries, 2) browsing of Government solicitation text such as the SBIR guide.

RESOURCES

Project Engineer: Daniel Lewallen
WL/MTIA (513) 255-7371
Contractor: Synchronetics, Inc.

STATUS

Complete
Start Date - February 1990
End Date - July 1990

CONTRACTOR INTEGRATED TECHNICAL INFORMATION SERVICES (CITIS)

CONTRACT NUMBER: F33615-89-C-5708, Task #62

STATEMENT OF NEED

Although substantial improvements are being made regularly in today's computer environment many existing contractor technical information systems are, at best, only partially integrated. That is, only a portion of the data stored in them and the functions performed by them are consistent or compatible, requiring little or no translation. In order to achieve an "integrated" environment, functional and technical standards defined in the context of a standard reference architecture are needed for building or retrofitting contractor technical information systems to support a specific weapons system program. Technical standards will facilitate the inter-connectability of computing networks and functional standards will define Contractor Integrated Technical Information Service (CITIS) from the end-user perspective.

APPROACH

This is a task under the Manufacturing Technology Special Studies contract (MTSS, F33615-89-C-5708). To support the stated objectives, the contractor will formulate and describe a CITIS operational concept which will be compared to the 31 December 1990 MIL-C-CITIS Functional Specification (Draft). The operational concept will address requirements and associated conformance measures applicable to Sections 3 and 4 of the Specification, derived from both emerging and production systems, and result in a recommended CITIS Implementation Plan for the emerging system. The operational concept will address the full range of issues necessary to implement CITIS and will identify: 1) potential contracting approaches and issues from the government and industry viewpoints; 2) applicable technologies and products available at the time of evaluation; 3) analysis of benefits to government and industry from the implementation of CITIS, including sources of costs and benefits; 4) needed technologies and/or products which would enable more effective implementation of CITIS, along with an assessment of the benefits resulting from such improvements; 5) an assessment of the constraints placed on CITIS implementation by existing infrastructure (including policies, procedures, systems and people); and 6) recommended changes to that infrastructure which are required to enable the CITIS implementation contemplated by the conceptual design.

BENEFITS

CITIS for a specific weapon system will provide inter-connected computer networks and application software that are utilized by members of the weapon system development team to enter, update, manage, and retrieve data from their own internal technical databases. In addition to requiring integration of the prime contractor's internal data and processes supporting a specific weapon system, the CALS Phase II Architecture for CITIS will further specify integration of prime contractor data and processes with subcontractor and vendor data and processes and with government-furnished information (GFI). The logical integration of prime, subcontractor, vendor, and government information for a specific weapon system creates an Integrated Weapon System Database (IWSDB).

STATUS

Active
Start Date - September 1991
End Date - September 1992

RESOURCES

Project Engineer: Dennis Rogosch
WL/MTIB (513) 255-7371
Contractor: Lawrence Associates, Inc.

PDES APPLICATION PROTOCOL FOR ELECTRONICS (PAP-E)

STATEMENT OF NEED

CONTRACT NUMBER: F33615-91-C-5718

The Air Force has a wide variety of electronics components developed by many sources. The need for product data from these sources for the integration, test, repair, integrated diagnostics, and reprocurement of these components is currently a critical problem. With the introduction of increasingly complex electronics in defense systems, the need for accurate and readily available digital product data has increased and the lack of such product data threatens to reduce the Air Force's ability to support its complex electronic systems.

The lack of a common product data exchange standard and methodology for product data exchange is considered to be of critical importance fo. electronics vendor survival, and for Air Force support of complex electronics. There are several electronics uata standards which provide different electronics product data coverage in support of different development and life cycle support activities. The development of a common approach to the use of these electronics data standards during the development and support of a product and for the representation of critical product data items will provide the common thread which is needed to bring about the wholesale use of product data exchange within the electronics development and computer aided design (CAD) communities.

APPROACH

The Air Force is interested in the formation of a set of allied applications. These will be used to (a) focus on a limited set of functions and document the required functionality in a human interpretable functional model, (b) further focus and document the resulting information needs in a context dependent human interpretable information model, (c) develop a computer interpretable information model and associated mappings where the model is based on the Product Data Exchange Standard and the Standard for the Exchange of Product Data (PDES/STEP) Generic Product Data Model (GPDM), (d) assure the development of appropriate conformance and validation criteria, and (e) populate a data base substantiated with product data representing an electronics product and demonstrating the platform, tool, vendor, and data format independence of the PDES representation and exchange methodology.

By allowing for the potential to integrate related Application Protocols (APs), a useful and implementable application protocol set for electronics can emerge. Efforts to standardize rely heavily on human agreement and practical application. It is therefore essential to maintain close coordination with the standards-making bodies and the product data community at large as an integral part of developing the application protocol set.

Many models have been and are being developed by the PDES and STEP communities. The process of normalizing, validating, and integrating the models is an enduring task. The development of a broad variety of APs is needed to test the functionality of the resulting models. Therefore, this project provides an opportunity to not only support the specific applications, but properly integrated and coordinated, to also help allied projects and be used as a verification of the product data specification process.

BENEFITS

This project will provide the first implementation of PDES application protocols for the electronics domain. In so doing it will set the stage for the insertion and adoption of PDES technologies in the electronics development communities. In addition, the project will provide activity and information models for use by the electronics development and tool support communities in lieu of the PDES formal standards adoption. This model availability will permit the beginning of product data exchange between electronics developers, integrators, test, and life cycle support activities.

The development and demonstration of the developed models from this program will provide the impetus for the adoption of increased product data exchange within the electronics communities, which will provide for more cost efficient product development and life cycle support. With 50% of the development costs associated with Printed Circuit Boards, Line Replaceable Modules, and Shop Replaceable Units contained in the test functions and with the electronics obsolescence problem costing millions of dollars each year, the application protocol developments selected for this project have been made to provide a high return on investment for the Air Force funds invested in this project.

STATUS

Pre-Award

Projected Start Date - September 1991

RESOURCES

Project Engineer: Bill Russell
WL/MTIA (513) 255-7371

Contractor: To Be Determined

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FORM - FEATURE APPROACH TO CYLINDRICAL PART RECOGNITION

CONTRACT NUMBER: F33615-90-C-5012

STATEMENT OF NEED

In the manufacturing environment, engineering drawings are used to convey information of a part to be manufactured to the pertinent sectors of the production functions. A good engineering drawing consists of a complete description of the product with regard to its geometry and attributes. Such information is used to extract the necessary features for manufacturing purposes. The engineer represents the features in terms of geometry which undergo an interpretation process when the time comes for manufacturing to reconvert the geometry back to the feature. Therefore, if a product can be described or modeled in terms of features, the manufacturing cycle can be reached and fewer errors due to the interpretation process will occur.

The objective of this research is to develop algorithms and implement them in a computer system for part recognition from a multiview engineering drawing for a cylindrical part. The expert-like system will take an Initial Graphics Exchange Standard (IGES) file and transfer it into a part definition data file by extracting the form features, their attributes, and other needed information. The extracted data will be structured according to Product Data Definition Interface (PDDI) and Product Data Exchange Standard (PDES) such that the definition data file will be readily interpretable by Computer Aided Design/Computer AidedManufacturing (CAD/CAM) systems. This project will be able to understand center lines, hidden lines, dimension lines, texts, omissions and abbreviations in a drawing.

APPROACH

Specific tasks to be accomplished in this study are: 1) completion of a comprehensive list of form features for cylindrical parts definition based on Product Data Definition Interface (PDDI) and Product Data Exchange Standard (PDES); 2) identification of needed attributes for each of the form features; 3) development of the algorithms to identify internal features, non-concentric features, and various views; 4) development of a natural language processor for texts and dimensions to supplement the recognition process; 5) development of learning capability to incorporate new shapes and features; 6) implementation of the developed algorithms in a computer, and 7) demonstration of the operation of the system and the use extracted part definition data file for direct NC program generation.

The procedure for part feature recognition and definition from an engineering drawing includes the following steps: 1) scanning and digitization of an engineering drawing; 2) character recognition; 3) vectorization of the digitized graphic image; 4) separation of individual views; 5) 2-D shape recognition; 6) text analysis; 7) 3-D geometric elements recognition; and 8) 3-D object recognition and presentation.

BENEFITS

Using part features for part definition has at least two advantages: 1) the shape of the part is captured in form features, which is essential to a number of CAD and CAM activities, and 2) the symbolic nature of the part definition data is in line with other computerized manufacturing systems requiring intensive human expertise.

Developing a computer system that will automatically extract part features from a multiview drawing and define them in a format for existing CAD and CAM systems is an important issue to CAD/CAM integration. This system will further reduce manufacturing lead time and thus improve productivity. This effort will also contribute to the general knowledge of computer vision and object recognition.

STATUS

Active
Start Date - June 1989
End Date - March 1994

RESOURCES

Project Engineer: 1st. Lt. Robert Stauffer
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Contractor: North Carolina A & T State University

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INTEGRATED TOOL KIT AND METHODS (ITKM)

CONTRACT NUMBER: PRDA 90-11

STATEMENT OF NEED

Currently, products to support developing standards are very slow to market and contain innaccuracies. Developers spend a great amount of money and effort in alpha and beta testing of these products. The development of effective system integration modeling methods has been a key area of focus within Wright Laboratory's Manufacturing Technology program. The objective of the Factory-of-the-Future project was to develop a set of integrated centers of excellence for aerospace manufacturing. To accomplish this objective, a set of methods were developed to analyze and simulate these functional centers and the information flow required to optimally operate these centers. The modeling methods designed to meet the requirements of this program were the Integrated Computer-Aided Manufacturing Definition Languages (IDEF0, IDEF1, IDEF1X, and IDEF2).

The IDEF methodologies have been used successfully in Department of Defense and commercial industry projects. The focus of the ITKM project is to build a set of integration tools which enhance and compliment the current set of IDEF methods.

ITKM is a Program Research and Development Announcement (PRDA) with multiple awards. Three programs will significantly contribute to the library of tools which can be used for integrated system development and enterprise integration.

The objective of this program is to provide an accurate reference implementation of network protocols to be used to test standards and product accuracy.

APPROACH

The program conducted by the Industrial Technology Institute will link models developed in IDEF modeling applications to commercial graphical and statistical manufacturing simulation packages. The IDEF models will provide information and data directly to these simulation packages. This integration of requirements analysis tools and simulation tools will provide a capability to test the accurateness and capability of the modeled systems.

The Corporation for Open Systems will provide an expert system based architecture to build and test reference implementations of standards based communication and network protocols. Current network product releases require long durations and do not always operate according to the network standards specifications. The reference implementations will provide network installers and network product developers the capability to verify the correctness of their systems and products. The use of the protocol reference implementation will increase the first time quality of network products and decrease time to implementation from 30% to 50%.

The Ontek Corporation will utilize the IDEF methods and other system modeling methods to provide a user friendly design interface to the PACIS (Platform for the Automated Construction of Intelligent Systems) representation system developed under the Advanced Airframe and Assembly Program and the Integrated Information Support System.

STATUS

Active
Start Date - August 1991
End Date - February 1993

BENEFITS

A decrease is projected in development time for compliant products. Accurate implementations at protocols and network products should reduce system development time 20-30% and system development cost.

RESOURCES

Project Engineer: Bruce Stucke
WL/MTIA (513) 255-7371

Contractor: 1) Industrial Technology Institute
2) Corporation for Open Systems
3) Ontek Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

GEOMETRIC MODELING APPLICATION INTERFACE PROGRAM (GMAP)

CONTRACT NUMBER: F33615-85-C-5122

STATEMENT OF NEED

No effective means of communicating part descriptions (geometry, material, tolerance, administrative data) between all organizations and functions in a factory exists today. With the proliferation of computer aided technologies such as computer aided design/manufacturing/engineering (CAD/CAE/CAM), more part data is needed and this need is expected to grow. Currently, paper engineering drawings, pictorial process plans, tooling drawings and inspection plans are used to communicate between islands of automated technologies. This manual or paper interface is not a time effective, accurate method of communication for the future integrated and automated factory. In the case of jet engine components, such as turbine blades and disks, complicated shapes and geometries must also be described. In the CAD modeling of these components, computer aided design models of air cooled jet engine blades and disks cannot effectively be communicated to manufacturing and logistics because of basic incompatibilities between system hardware and software.

APPROACH

Five technical tasks were employed in GMAP to fulfill its objectives. Task I, "Understand the Problem", consisted of three subtasks. Subtask 1.1 was a comprehensive subtask encompassing the establishment of an Industry Review Board, Product Assurance/Quality Assurance plans, coordination with other Computer Integrated Manufacturing projects, selecting a part family for study, and performing a high level functional analysis of the applications involved in the life cycle of the selected part family. Subtask 1.2 included determining GMAP application interface needs using a "walk-through" of a product's life cycle. Subtask 1.3 established the "to-be" system requirements from the identified needs, and completed a State-of-the-Art Survey of existing capabilities that identified both the minimum, and the functional, requirements of a product modeler.

Task 2, "Establish the Preliminary and Detailed Design", consisted of four subtasks. In Subtask 2.1 a conceptual design for GMAP was developed, including identification of required enhancements to Product Definition Data Interface (PDDI) technology and a plan for testing the GMAP system software. In subtask 2.2 this work was reviewed to ensure that the design met all of the system requirements established in Task 1. Subtask 2.3 detailed the design, and established plans for testing logistic application interfaces. Subtask 2.4 ensured review of the detail design.

Task 3, "Integrate Existing Functional Applications", consisted of designing interfaces for two existing functional applications, the Retirement for Cause disk inspection system and the Integrated Blade Inspection System, at the Air Force's San Antonio Air Logistics Center.

In Task 4, "Build and Integrate the Application Interface", GMAP software was constructed and the function, performance, and integration of the system was verified in accordance with the design and test plans established in Tasks 2 and 3. Applicable manuals were produced for the installation and operation of the system.

Task 5, "Implement, Maintain, and Demonstrate GMAP", included four subtasks. Subtask 5.1 demonstrated the effectiveness of the GMAP system by implementing it on contractor, customer and outside supplier computer systems. Subtask 5.2 provided modifications to the GMAP system during testing as required. Subtask 5.3 identified the potential benefits if GMAP was fully implemented on life cycle applications. Under Subtask 5.4, several videotapes were produced to demonstrate the GMAP system performance.

BENEFITS

The GMAP program focused on the computerized generation, control, and exchange of traditional engineering design and manufacturing data. GMAP extended the PDDI information model to include computerized support applications for the entire life cycle of a product. GMAP specifically applied product life-cycle support, including engineering, manufacture, inspection, and logistics support, to cooled jet engine turbine blades and disks. GMAP has provided vital technical research and design pertinent to product data description which is utilized as a base line for PDES product data models.

STATUS

Complete
Start Date - August 1985
End Date - August 1990
Final Technical Report: WRDC-TR-89-8038, Volumes I & II

RESOURCES

Project Engineer: Alan Winn
WL/MTIB (513) 255-8787
Contractor: Pratt & Whitney

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

PRODUCT DATA DEFINITION INTERFACE

CONTRACT NUMBER: F33615-82-C-5036

STATEMENT OF NEED

Initial Graphics Exchange Specification (IGES) activity was initiated by the requirements of industry for a near-term solution to the needs of interfacing graphics systems. The need for a near-term solution was precipitated by organizations that had purchased systems from different vendors, and organizations that understood the advantage of direct digital-data exchange with suppliers and subcontractors.

The problem was that each computer aided design (CAD) vendor typically has a unique and proprietary "native" format for the representation of data necessary to define a product. In order to make use of information generated by one CAD system (A) on a second CAD system (B), a translator must be developed to go from A's native format to B's native format, and a second translator developed to go from B's native format back to A's. This problem grows quickly as more CAD systems are added - six translators are required for three different CAD systems. As a way of circumventing this customized translator development problem, IGES defines a "neutral" data file as a means of linking dissimilar systems.

This work is concerned with four fundamental objectives regarding IGES: establishment of a test methodology and procedures to evaluate IGES translators, determination of the extent to which IGES defines product definition data, evaluation of the level to which the CAD vendor/user community has been able to implement IGES, and the identification of problems in current implementations.

The objective of this program was to develop and demonstrate an exchange specification which would allow the replacement of engineering drawings with an electronic interface between engineering and manufacturing functions.

APPROACH

The Product Data Definition Interface (PDDI) Project was organized into two tasks:

- Task I - Evaluation and Verification of the Initial Graphics Exchange Specification (IGES).
- Task II - Development and Demonstration of a Product Definition Data Interface.

The approach taken to address these issues involved field tesing of twelve different CAD systems to assess their ability to generate and interpret production definition data in an IGES format. The tests did not exhaustively examine every aspect of IGES but did provide an in-depth evaluation of 1983 IGES implementations and, as such, identified specific problems encountered with versions of vendor/user IGES software. In addition, improvements that can be made to the Standard to positively impact translator development and operation were determined. These tests represent the most comprehensive evaluation of IGES performed to date. Version 1.0 of IGES has now been incorporated as part of an American National Standard (ANSI Y14.26M-1981). Later versions of IGES are at various stages in the cycle of updating the ANSI Standard.

BENEFITS

The test methodology established in this project can serve as a baseline from which future test methodologies for subsequent versions of IGES can be developed. In addition, the test results of this effort of have served as a valuable source of baseline information for subsequent work.

STATUS

Complete
Start Date - June 1982
End Date - July 1989
Final Technical Reports: AFWAL-TR-84-4044, Volumes I-IV
FTR560130000A

RESOURCES

Project Engineer: Alan Winn
WL/MTIB (513) 255-3787
Contractor: McDonnell Douglas Corporation

OBJECT BASED INTEGRATED DESIGN (OBID)

CONTRACT NUMBER: F33615-89-C-5709

STATEMENT OF NEED

The use of database and communications standards like the Structured Query Language (SQL) and the Open Systems Interconnection (OSI) have enabled engineers and designers to access a large variety of databases to support their activities. This expanse of available technical information created a need to manage the design and engineering process. A method was needed to coordinate the steps in a design process, the applications used in that process, and the data needed to support those applications.

The objective of this program is to create an object oriented design engineer assistant in a parallel processing and database management environment.

APPROACH

The approach was to create a knowledge based shell which a process expert could use to develop a model which would link the applications used in the design process to the proper data resources. This model also included a facility to include rules within this process model so decision criteria could be used based on the results of the applications activated within the shell. Applications would automatically trigger as each step in the design process proceeded. The applications could be launched sequentially or in parallel if the appropriate information was accessible.

The OBID program was performed under a Small Business Innovative Research (SBIR) Phase II project performedby Universal Energy Systems (UES). The implementation and commercialization effort was focused on two pilot sites, the Team Columbus/ McDonnell Douglas Facility in Columbus, Ohio and The Allison Gas-Turbine Engine Plant in Indianapolis, Indiana.

The OBID Knowledge Integration (KI) shell was used at Team Columbus to provide a means of automating the Team design process. In the team organization, the typical organizational hierarchy is flattened and members are designated to teams which produce a certain type of product. The teams are multi-disciplined containing engineering, manufacturing, planning and financial persons. The KI shell provided a way to develop a management strategy which guided team members unfamiliar with all aspects of producing a product. The shell was able to instantiate the role of the team member and guide them through their steps in the product development process. The KI shell was a key enabling technology and contributed to the success of implementing true product teams at the Team Columbus facility.

The Allison Engine facility used Triad, a commercialization of the KI shell sold by IBM under a licensing agreement with UES. Allison developed a prototype blade design system which used the KI shell to help sift through piles of aerodynamic and finite element analysis data. Not only was designed time reduced from weeks to days, but because of the speed of the design iterations, designers can now work on optimizing blade design instead of accepting a first feasible design because of the time constraints.

STATUS

Active
Start Date - September 1989
End Date - December 1991

BENEFITS

The knowledge integration shell provides a process expert, the ability to guide the development of a product, based on the correct invocation of design and analysis applications. The question of which application to run next and which data to access can be predetermined. This ability has been proven to cut design time of components like compressor blades by 60%.

The OBID project has also provided the ability to build knowledge shells which can guide the activities and functions of an organization as they were designed to be performed. The shell can duplicate the activities designed in functional and process models like those provided by the IDEF tools. UES has continued to build a library of generic process models which can be used as a starting point to design company specific process models. This philosophy can provide companies important building blocks to interating their particular processes.

RESOURCES

Project Engineer: Brian Stucke
WL/MTIA (513) 255-7371
Contractor: Universal Energy Systems, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

COMPUTER-AIDED CURING OF COMPOSITES

CONTRACT NUMBER: F33615-73-C-5036

STATEMENT OF NEED

Due to high reject ratesther is a need to drive down the composite production costs related to curing. Evidence from other projects indicates that improvements can be made using computer-aided techniques. These include simulation and real time control.

The objective of this program is to develop and demonstrate computer-aided systems for the simulation and real time control of the structural composite curing process.

APPROACH

The overall approach was a systematic one in which necessary technologies were developed and then integrated into a working methodology that will provide the initial capability to perform off-line cure simulation and part batching arrangements. The ultimate goal was to achieve real-time control of the curing process. This effort evolved further through feasibility demonstrations in which the methodologies were comprehensively validated. The program consisted of three phases:

Phase I - Enabling Technologies Development and Feasibility Demonstration

Phase II - Component Demonstration

Phase III - Automated Control of the Manufacturing of Starting Materials.

In Phase I, basic research and exploratory development activities were conducted to (1) develop a complete mathematical model of the curing process, (2) develop the capability for batch processing, and (3) develop a real-time control system for autoclave cure. These capabilities were developed and integrated, and the feasibility and economics of the system are now being demonstrated. The final task of Phase I was to determine the influence of starting materials variability.

In Phase II, the computer-aided curing system was demonstrated in a production environment. The cure optimizer software has been modified to allow for optimization of an entire autoclave load. Both computer-aided processing and standard state-of-the-art processing were used to fabricate and cure selected aircraft parts. The quality of the parts was determined by nondestructive testing and physical and mechanical properties. A comparison was made between the computer-aided cured parts and the standard cured parts.

In Phase III, manufacturing controls were developed to reduce prepreg supplies. The mixing operation was modified and necessary control software was developed for a twin-screw extruder. Following model verification and control system refinement, materials were produced by Hercules, Inc. and tested by both McAir and Hercules, Inc.

BENEFITS

Principal cost benefits resulted from increases in the number of parts per batch and through improvements in load and unload time. Additional benefits accrued due to quality improvements.

STATUS

Complete
Start Date - May 1983
End Date - June 1990

RESOURCES

Project Engineer: Francis Abrams
WL/MLBC (513) 255-9015
Contractor: Hercules, Inc.

MANUFACTURING SCIENCE

RELIABILITY WITHOUT HERMETICITY (RwoH) FOR MULTI-CHIP PACKAGING (MCP)

CONTRACT NUMBER: F33615-91-C-5710

STATEMENT OF NEED

The extreme environmental and lifetime service requirements of integrated circuits (ICs) in military applications have required hermetically sealed electronic devices and prevented the use of coatings often used by the commercial electronics manufacturers (e.g. telecommunication, computers and automotive products). Organic (polymeric) and inorganic coatings can provide significant advantages.

This program addresses electronic packaging approaches which take advantage of technology gains which have been made in the commercial device community. There is the opportunity to achieve more than 100 times the current system performance while increasing reliability, and maintaining supportability/affordability requirements.

The objective of this program is to develop the fundamental manufacturing science required to obtain coating systems that achieve reliability without hermeticity in multi-chip packages (MCP's). The overall goal of this effort is to establish sets of coating materials and processes compatible with high density MCPs.

APPROACH

This effort addresses the major areas of development and manufacturing, identified through analyses, whose goal is to preserve device performance throughout the Packaging and Interconnect (P&I) hierarchy. In each area of work, the electrical, mechanical, thermal, and chemical stresses will be thoroughly analyzed and minimized.

Specifically, those areas are surface protective coatings of the electronic assembly. Organic and/or inorganic surface protective coatings will improve the yield and cost of the multi-chip package (MCP) as well as eliminate the classical hermetic sealing of the multi-chip packaging. Therefore, poor performance refractory metals will no longer be required and system level speed will be enhanced. A primary goal is to make the package initially reliable enough to eliminate the need for repair, i.e. a throw-away module.

The project will include efforts in fundamental studies at Lehigh University in materials interactions, failure mechanisms, degradation mechanics and modeling. The material processing, experimental evaluations, and investigation of accelerated environmental test methodologies will take place at Microelectronics & Computer Technology Corporation (MCC) and at the participants' facilities. This will help accelerate existing efforts. For example, the Environmental Research Institute of Michigan (ERIM) is developing an innovative testing technique which will be extended by the RwoH Project and used to verify the experimental approach.

BENEFITS

The primary benefits of this effort will be to increase performance and reliability; reduce cost; and produce modules with a "failure-free" life (approximately 50,000 hours).

An important benefit is that the cooperative project approach will help form an effective link between users, suppliers and researchers by providing a forum in which these groups can interact. This forum, in cooperation with Rome Laboratory, also provides an environment for the generation of appropriate specifications that will be used for the qualification of new non-hermetic MCPs.

The payoff is reliable, high yielding and affordable multi-chip packages with 10 to 100 times more performance than the current high cost, low density, hermetic packages.

STATUS

Active
Start Date - February 1991
End Date - September 1994

RESOURCES

Project Engineer: Capt. David Curliss
WL/MLBC (513) 255-1471
Contractor: Microelectronics & Computer Technology Corporation (MCC)

ADVANCED SENSORS FOR CONTROL OF EPITAXIAL (EPI) GROWTH

CONTRACT NUMBER: N/A

(In House WL/ML Research)

STATEMENT OF NEED

Each generation of new microwave, microelectronic, and optical devices requires more complex layer structures for the semiconductor materials from which the devices are fabricated. The control of layer thickness and composition is critical for many of the new devices since both function and performance is directly linked to these parameters. Growth techniques such as molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) have the potential to provide these complex structures, but in-situ evaluation of the layers during growth and real time feedback of corrective actions are required. In-situ evaluation of as-grown layers prior to exposure to the atmosphere will be beneficial for cases in which a passivation layer is to be deposited or additional layers are to be grown on the surface prior to exposure to the contaminating effects of the atmosphere.

The objective of this project is to develop in-situ generic sensor and control technology applicable to the epitaxial growth of semiconductor and optical materials.

APPROACH

The approach is to evaluate the growth process through modeling and simulation and to perform sensitivity analyses of the process variables using designed experiments. This data will provide an indication of which process parameters need to be tightly controlled and monitored. This program will establish which in-situ sensor and diagnostic techniques are required and install these sensors in the growth chamber. Our emphasis will be on non-intrusive (primary optical) techniques for evaluation of the material as it is grown layer by layer. The sensor information will be fed back for real time comparison with the required layer profile generated by a model. The growth of subsequent layers will be adjusted to finish with a corrected profile which performs the required function. The system will be evaluated by growth of semiconductor layers for specific microwave and optical applications.

BENEFITS

The largest projected benefit of this task will be its impact on the reproducibility of devices for Air Force systems. The increased device control is largely due to the measuring of real-time, relevant parameters for the growth process. Another benefit will be maintaining an edge on the critical U.S. technology of molecular beam epitaxy.

STATUS

Active
Start Date - 1991
End Date - December 1994

RESOURCES

Project Engineer: Kirk Eyink
WL/MLBM (513) 255-3625
Contractor: In-house research

MANUFACTURING SCIENCE

COMPLEX SHAPED THERMOPLASTICS

CONTRACT NUMBER: F33615-86-C-5008

STATEMENT OF NEED

The development of new aircraft such as the Advanced Tactical Fighter requires the increased use of fiber-reinforced composite materials to achieve the desired goals for range, speed, payload, and supportability. The advantages of the composite materials can be attained at lower costs by using new thermoplastic resin matrix materials in place of conventional thermoset resins. The major challenges with thermoplastic resin composites include the lack of a knowledge base on their processing characteristics, and the limited availability of suitable material forms for which optimum processing has been developed. In order to take advantage of the potential benefits of thermoplastic composites, an organized knowledge base must be developed. This will provide the basis for science-based processing development rather than traditional trial-and-error approaches, and will accelerate the application of thermoplastic composites in new military aircraft.

The objective of this program is to define, develop, and validate science-based thermoplastic processing methods for complex shape parts.

APPROACH

The program is divided into three phases: definition, process engineering, and laboratory feasibility demonstration.

The thermoplastics process simulation model developed in Phase I has been validated and updated through its application to the various placement/ consolidation/forming processes validated in Phases II and III. A prototype of the thermoplastics product definition system has been developed, consisting of a thermoplastic database and expert system. In Phase II, several innovative thermoplastic placement, consolidation and forming processes have been validated which offer the potential for significant cost savings. These processes demonstrate the unique processing capabilities of thermoplastics deriving from their melt/ flow characteristics and their ability to be reprocessed. These processes are: rubber-assisted press molding, diaphragm forming, therm-X, pultrusion, vacuum forming, and a dieless forming process. A laser/fiber optics energy delivery system was also developed.

In Phase III, two small scale components were fabricated to demonstrate the technologies validated in Phase II. The validation and demonstration phase of this program have achieved the objective of validating a science base for thermoplastics and validating and demonstrating low cost, innovative processes for fabrication of thermoplastic composite parts. In the welding/bonding add-on, the following processes have been screened and validated: low frequency induction welding, autoclave co-consolidation, vacuum co-consolidation, dual resin bonding, and ultrasonic welding. Mechanical characteristics of co-consolidation, ultrasonic welding, and dual resin bonding has begun.

BENEFITS

Development of processing methods for thermal plastic placement, consolidation and forming will result in a reduction of manufacturing costs for thermoplastic composites of as much as 30-40% for selected applications. The fabrication of small structural elements has validated these low cost, innovative processing technologies.

The development of a prototype/expert system for thermoplastics and the application and updating of a process simulation model will result in better prediction of materials response in processing. As a result, the learning curve will be steeper and money will be saved in the processing of thermoplastic composites.

The validation of joining methods such as ultrasonic welding and dual resin bonding will also result in lower manufacturing costs and will impact the repairability of thermoplastic component on Air Force weapons systems.

STATUS

Active
Start Date - October 1986
End Date - June 1992

RESOURCES

Project Engineer: Suzanne Guihard
WL/MLBC (513) 255-9728
Contractor: Lockheed Aeronautical Systems Company

RELIABILITY WITHOUT HERMETICITY (RWOH) FOR INTEGRATED CIRCUITS (IC)

CONTRACT NUMBER: F33615-90-C-5009

STATEMENT OF NEED

This effort addresses manufacturing science for integrated circuit (IC) protective coatings process development and evaluation. It is part of an overall initiative addressing novel coating systems. The coatings are to be evaluated using innovative approaches to defining, analyzing, and trading-off the assembly process characteristics, and the electrical, thermal, mechanical, and chemical stresses associated with protective coatings for integrated circuits and multi-chip packages.

The objective of this program is to develop the fundamental manufacturing science required to obtain coating systems that achieve reliability without hermeticity in multi-chip packages (MCP's). The overall goal of this effort is to evaluate and test the industry's most promising integrated circuit (IC) coating material for application in military systems. The data provided should establish the baseline technology directions for the eventual coating of MCPs. The coating to be evaluated is the Dow Corning Surface Protected Electronic Circuits (SPEC) coating.

APPROACH

A ten step approach is contemplated: 1) evaluate (as a minimum) the Dow Corning SPEC coating in combination with National Semiconductor's "TAPEPAK" approach for Integrated Circuit (IC) packaging; 2) select devices to be coated; 3) engineering studies will be conducted to minimize the chemical, thermal and mechanical characteristics of the coating; 4) a leadframe coating process will be developed; 5) device test samples will be established; 6) the test samples will be coated with an SiO_2 planarizing layer and an SiC barrier layer; 7) the test samples will be overmolded with plastic (approximately 150 devices); 8) Reliability testing and comparison of 50 devices in ceramic packages (hermetic control units), 50 devices in plastic packages with no SPEC coating, 100 devices in no plastic packages with SPEC coating, and 50 devices in plastic packages with SPEC coating will be conducted. The tests will include Highly Accelerated Stress Testing (HAST), salt atmosphere, temperature cycling, and autoclave testing; 9) the contractor will evaluate long-term reliability of SPEC coated devices by a variety of tests and MIL-STD-883C methods; 10) failure analyses will be conducted on all test failed devices.

The number of analyses will be a representative sample. Failure analysis will include optical microscopy, electrical characterization, scanning electron microscopy, elemental X-ray analysis, and auger analysis.

BENEFITS

Considerable cost savings by using plastic packages in place of ceramic; improved mechanical protection of electronic devices; decrease in weight of most electronic systems by using plastic; reduced dependency on foreign sources; compatibility with wire bond technologies; direct ceramic-to-plastic package conversion; increased government knowledge in this technology area.

STATUS

Active
Start Date - February 1991
End Date - March 1993

RESOURCES

Project Engineer: Capt Michael Marchese
WL/MLSA(513) 255-2623
Contractor: National Semiconductor

MANUFACTURING SCIENCE

COMPUTER - AIDED ENGINEERING (CAE) SYSTEM FOR DIE DESIGN

CONTRACT NUMBER: F33615-83-C-5052

STATEMENT OF NEED

In order to reduce manufacturing costs and to provide surge capability in acquiring and manufacturing components of Air Force systems, the vendor-user relationships and the scientific base for designing unit production processes must be improved. Productivity of the unit processes, such as forging, injection molding, casting, welding, rolling and so forth, can be improved significantly by appropriate use of computer-aided engineering (CAE) techniques. A true computer simulation (process model) of a unit process can predict and control the geometrical as well as the metallurgical variations that occur in the material in a given unit process. At this time, there is no integrated method for simulating and optimizing such processes by taking into account all process variables, such as the part geometry, the material characteristics, the material-tool interface effects, the process mechanics, and the product microstructure and properties.

APPROACH

This program was conducted by Shultz Steel (prime contractor) and Battelle (first tier subcontractor). Two universities (The University of California and The Ohio State University), an airframe builder (McAir), an engine builder (General Electric Aircraft Engines), and two aerospace forging companies (Wyman-Gordan and Cameron). This program was conducted in the following phases:

Phase I- Engineering Analysis and Geometric Data Base

Phase II- Forging Materials Design Data Base

Phase III- Process Simulation and Tooling Design Software

Phase IV- Blocker and Finisher Dies Design Programs

Phase V- Economic Modeling Program

Phase VI- Validation of Computer Aided Engineering System

The final phase of the total CAE system validation was concluded by going through an entire die design manufacturing sequence. Parts either in production or in design was selected, and all steps necessary for CAE design and manufacture of the dies for the selected parts was emulated.

BENEFITS

This program:

- Reduced die design, manufacture costs, and lead and delivery times.
- Reduced process/die setup time, increased equipment utilization rates, increased equipment capacity, and reduced investment requirements for additional production capacity.
- Improved productivity and surge capability.
- Increased consistency and quality.
- Reduced dependence on scarce skilled tool and die makers.
- Made near net and net forging more cost effective, thereby reducing the need for strategic materials and machining costs.

The benefits vary. Forge cost reduction was from 30 to 50 percent, and delivery times were reduced by 50 to 70 percent. Therewere also concomitant increases in product quality.

STATUS

Complete
Start Date - January 1984
End Date - January 1989

RESOURCES

Project Engineer: William O'Hara
WL/MLLN (513) 255-1995
Contractor: Shultz Steel Company

KNOWLEDGE INTEGRATED DESIGN SUPPORT (KIDS) SYSTEM

CONTRACT NUMBER: F33615-89-C-5619

STATEMENT OF NEED

A prime aircraft or engine contractor will typically subcontract up to 80% of the components of the system. In today's environment, the design engineers are not able to address such factors as manufacturing alternatives, the best combination of processes for producibility and reliability, etc. It is also difficult to evaluate the opportunities for introducing new materials and processes which have the potential for increasing performance and reliability of the aerospace system within the time period allowed for concept design and by the end of system definition, where 85% of the cumulative life cycle costs are fixed. The problem is compounded because there is an explosion of knowledge as the design proceeds: the computational times are too long for real-time analysis and process design evaluation, the Computer-Aided Desig. Manufacturing/engineering (CAD/CAM/CAE) tools needed for process design are not integrated and data bases having different data models are difficult to access.

The Knowledge Integrated Design System (KIDS) project will develop a powerful engineering workstation which will utilize parallel processing techniques and engineering workstation knowledge integration. It will produce a total design capability which incorporates producibility and supportability. This project will build off previously established technologies and tailor specific strategies for reducing design and manufacturing cycle times.

APPROACH

This program will provide the designer with a high-performance workstation using precision casting as a model system and a methodology which: (a) enforces all the skills needed for "simultaneous" production and process design and development in a systematic way, (b) provides specialized knowledge integration software at the exact moment it is needed, (c) provides a methodology for backward integrating materials and parts vendors with manufacturing organizations, and (d) emphasizes performance of the designer at the workstation.

The approach is to focus on design as a cooperative problem solving activity involving many different types of solving agents, such as the engineer, expert systems, finite element method analysis packages, etc. Analytical application packages for conceptual and detailed design will be integrated by means of intelligent or knowledge integration software to allow autonomous and heterogeneous software and hardware systems to communicate as though they were a single apparent system. The integration of information data bases, application packages, enhanced performance of the designer, and increased computational power at the local level of a network will be the primary objectives of this project.

BENEFITS

This manufacturing science project will provide the process designer with a high performance workstation. It will reduce the cycle times required for process design by up to 10 times making it possible to evaluate process alternatives. This will enhance the possibility of making use of new processes and materials for increasing producibility, reliability and performance in real time. The increased performance will translate into major cost savings through such factors as reducing cycle times, eliminating costly shop floor trial-and-error development, increasing the possibility for utilizing new materials and processes, increasing the efficiency of manufacturing, and increasing the quality of the product on a repeatable basis.

STATUS

Active
Start Date - March 1990
End Date - July 1994

RESOURCES

Project Engineer: William O'Hara
WL/MLLM (513) 255-1995
Contractor: Universal Energy Systems, Inc.

MANUFACTURING SCIENCE

ADVANCED COMPOSITE PROCESSING TECHNOLOGY

CONTRACT NUMBER: F33615-88-C-5455

STATEMENT OF NEED

Because of the specific properties and behavior characteristics of advanced composites, this class of materials is offering tremendous performance payoff for advanced aerospace military systems. The structural weight of current production aircraft consists of ten to twenty percent composites and is projected to be more than fifty percent on future systems. The manufacturing costs of this class of materials will play an increasingly important role in the cost drivers of future Air Force systems.

Composite components are being manufactured in a manner that was developed based on cumulative trials and errors and prior experience. The cure cycle employed is not necessarily the most efficient. The quality of the products varies and depends very strongly on the experience and skill of the workers. Costly quality control measures are implemented to ensure these factors contribute to the added cost of manufacturing organic matrix composites. Employing artificial intelligence (AI) techniques in the manufacture of these parts can minimize the added cost. The knowledge base and supporting technologies are lacking and need to be developed to implement AI efficiently.

Based on the recent advances in the computer technology and the science of artificial intelligence (AI), the future manufacturing environment is predicted to utilize AI control for lowering manufacturing costs and improving component quality. The AI technique of sensor fusion has been successfully demonstrated for composite processing through an approach identified as Qualitative Process Automation (QPA).

APPROACH

This program is to further develop the techniques for utilization in industrial production environments and to ensure the transition of the QPA technology into advanced composite manufacturing.

This program is being addressed in four tasks. Task 1 was the development of production-hardened sensors, completed in November 1990. Task 2 provided advanced control-rule strategy; testing is complete and data analysis underway. Task 3 integrated these elements into the quality processing automation system for demonstration; this knowledge base has been successfully run on a simulator. Task 4 adds academic involvement; Washington University in St Louis will model two condensation curing polymers. When the models are complete, knowledge base rules will be written and actual experimentation will be conducted. This knowledge will be transitioned to McDonnell Douglas Aircraft Company for part fabrication.

BENEFITS

The benefits of this project are lower manufacturing cost for organic matrix composites and production-quality consistency that will result in overall lower acquisition cost of weapon systems and better component reliability.

QPA can help reduce development time for new materials by approximately 50%, and can reduce the autoclave time by approximately 30-50%.

STATUS

Active
Start Date - February 1989
End Date - September 1992

RESOURCES

Project Engineer: John Russell
WL/MLB (513) 255-9062
Contractor: McDonnell Douglas Aircraft Company

MANUFACTURING SCIENCE RUGATE FILTER PROCESS AND PRODUCTION

CONTRACT NUMBER: F33615-86-C-5059

STATEMENT OF NEED

Achieving the optical performance specifications for advanced military electro-optical systems required the conception and development of a new class of electro-optical filters called rugate filters. In contrast to multilayer quarter-wave stack filters, rugate filters exhibit exceedingly narrow reflection bands with very high reflectivity and no sidebands, thereby giving high out-of-band transmission. The fabrication of rugate filters requires a quantum jump in the production technologies currently used by the thin film optics industry. In particular, the innovative and intricate optical properties of rugate filters necessitate the use of advanced computer augmented processing and control of the deposition process.

APPROACH

This program defined and developed the optical monitors and process control system to implement a completely closed-loop, real-time feedback system. Ion assisted physical vapor deposition with E-beam and resisted sources is the baseline deposition process to which the optical monitoring techniques, scanning photometry, interferometry, and ellipsometry were developed.

Sensor fusion is a key consideration in developing the control system. The control system architecture consists of three layers: the lowest layer consists of board-level computers controlling individual optical monitors and is responsible for passing data to the process control computer; the middle layer is responsible for interaction (sensor fusion) of data and process control; the top layer (supervisory) monitors overall system performance, tracks long-term trends, initiates redesign of the rugate filter index profile to correct for production errors, and provides an operator interface.

Expert-system technology enhances the process controller in both the top level and the lower level controllers. At the supervisory level, the expert system aids in appropriate design selection. With the "Design for Manufacture" philosophy, the expert system assesses the input design and determines the feasibility of the design given the equipment constraints. An alternate design may be suggested. During fabrication, the expert system provides support for trend analysis and can recommend corrective action. At the control level, the expert system adjusts fabrication according to optical monitor inputs, as well as, status information received from the exception handler which monitors system operational parameters.

BENEFITS

The benefits of rugate filters over comparable stacks included: absence of rejection bands at harmonics, high out-of-band throughput, bandwidth control, multi-line design simplicity, design flexibility with less material dependence, and suitability for specific application adjustment with added line position and attenuation flexibility.

Other benefits of rugate filters are derived from the technology developed for rugate manufacture which can be applied to other enhanced optical coatings. The array of design tools developed for the program enable the prototyping of a new coating with minimal design input. A large volume of data was collected during rugate deposition (continuous runs from two to twelve hours depending upon filter design). A sophisticated analysis routine was developed for data interpretation which enables rapid detection, diagnosis, and repair of deposition failures.

Automated process control and innovativemanufacturing techniques have been implemented to expand the capabilities of the system hardware.

STATUS

Complete
Start Date - December 1986
End Date - March 1991

RESOURCES

Project Engineer: Pamela Schaefer
WL/MLPJ (513) 255-3808
Contractor: Hughes Dansbury Optical

MANUFACTURING SCIENCE

MANUFACTURING SCIENCE

MANUFACTURING SCIENCE OF CARBON-CARBON STRUCTURAL COMPOSITES

CONTRACT NUMBER: F33615-90-C-5902

STATEMENT OF NEED

With the advent of advanced hypersonic technology and propulsion requirements for future Air Force weapons systems, there is a need for very-high temperature materials and structures with excellent properties. Reasonable manufacturing costs are required to meet system goals. Carbon-carbon composites have been empirically developed during the past 25 years. They have been successfully applied to large number of critical defense applications such as the Peacekeeper and Small ICBM rocket nozzles and the MK12, MK12A, and MK21 re-entry vehicle nosetips.

Recent attempts to utilize this empirical manufacturing technique for new applications (e.g., turbine engine exhaust flaps) have failed. Scientific design, fabrication, processing and manufacturing methods must be developed in the production environment in order to effectively utilize carbon-carbon composites for advanced Air Force applications. Empirical approaches to advanced technology applications have proven to be high risk and lead to ineffective and costly materials development. In addition, the long lead-time required to produce carbon-carbon composites, expensive rejects, and rising delivery costs give great importance to the need for composite uniformity, reproducibility, and cost improvements through integrated manufacturing methods.

This effort is intended to integrate the knowledge about carbon-carbon processing that already exists, identify weaknesses in that knowledge which contribute to the difficulty in maintaining and ascertaining carbon-carbon composite quality, investigate those areas needing improvement, and demonstrate a better control over the manufacturing of carbon-carbon composites.

APPROACH

This project will be managed in two phases. In Phase I, "Enabling Technologies", the contractor will integrate enabling materials and process technologies that have been previously developed using applicable knowledge from both carbon-carbon and organic matrix composite industry and scientific experience. The contractor, with government approval, will select a team of experts to help in the assessment of information, planning of specific approaches, and dissemination of information. The contractor will then evaluate the overall knowledge based on manufacturing reproducible carbon-carbon composite structures. Selected experiments will be conducted to extend and enhance the knowledge base in critical areas or areas lacking in basic understanding. The contractor will develop an off-line computer model to be used in the development of a process strategy for intelligent process control and will use that model to do studies of the process. This knowledge will be used in a demonstration of materials and process design methodology by making structural subelements and panels.

In Phase II, "Automated Control of the Manufacturing Process", sensors and control architecture will be selected for intelligent controller(s) for the automation of the manufacturing process.

The model will be used, in conjunction with the intelligent controller, to develop a preliminary rule base for the control of carbon-carbon manufacturing.

Quality control specifications, including the in-process controls to be used, also will be selected and specified. Demonstration articles will again be selected, processed, and tested using this technology. The flexibility of the manufacturing strategy will be demonstrated by the use of the rule base and controls to make a structural subelement(s) out of a different material and/or process. The results and cost benefits analysis will be summarized and may be transitioned to industry through a potential follow-on MANTECH program.

BENEFITS

50% reduction in rejection; improved reproducibility; issues related to design manufacturing will be transitioned to industry; improved reliability; decreased costs through reduced scrap; more throughput; better use of equipment-energy; and approach to material and progress selection.

STATUS

Active
Start Date - June 1990
End Date - March 1995

RESOURCES

Project Engineer: Scott Theibert
WL/MLBC (513) 255-9067
Contractor: SAIC

MANUFACTURING SCIENCE FOR TITANIUM ALUMINIDE COMPOSITE ENGINE STRUCTURES

CONTRACT NUMBER: N/A

STATEMENT OF NEED

Advanced lightweight, high-temperature titanium metal matrix composite (MMC) materials are critical to the future international competitiveness of the U. S. turbine engine industry. They are crucial to the attainment of increased thrust-to-weight capacity in advanced high-performance engines. The high strength and low density of these materials will allow reductions in static structure weight and increase in rotational speeds. The high specific stiffness of these materials will allow tighter clearance tolerances to be maintained. Additionally, the application of MMCs with titanium aluminide matrices will provide increased compressor discharge temperature capability. The demonstration of these benefits for titanium aluminide composites is, however, currently limited by issues related to their fabrication. The inability to consistently and successfully fabricate these composites in the geometries needed for advanced engine applications stems from the lack of an adequate manufacturing science base.

APPROACH

This manufacturing science program will establish an understanding of the processing/fabrication methods for making hoop-reinforced rotating structures from continuous fiber reinforced titanium aluminide metal-matrix composites (MMCs). Examples of these hoop-reinforced rotating structures are the bladed rings, spacers, and drum rotors for 650-760° C (1200-1400°F) application in advanced turbine engine compression systems. This program will address the lack of understanding associated with the fabrication of composites, including not only the consolidation of composite structures but the production of input material for consolidation (e.g. titanium aluminide foil) as well.

The program will be conducted in three phases, beginning with an assessment of competing composite fabrication approaches, including both foil-fiber-foil and non-foil techniques (such as plasma spray, tape casting, cold spray, and physical vapor deposition). This assessment will include the identification of quality and reproducibility drivers (fabrication knowledge gaps). A statistically-designed series of experimental fabrication trials will be conducted in the second phase of the program to develop the needed science base for a selected number of fabrication approaches. The benefit of the knowledge gained in the second phase will be demonstrated in the third phase by the manufacture and evaluation of a number of like articles.

BENEFITS

Ability to produce titanium aluminide MMC components needed to achieve higher turbine engine thrust-to-weight ratios via a 200° C increase in compressor temperature capability and a reduction in overall compressor weight of approximately 50%.

STATUS

New Start
Start Date - September 1991
End Date - January 1995

RESOURCES

Project Engineer: Katherine Williams
WL/MLLN (513) 255-1367
Contractor: TBD

INNOVATIVE MANUFACTURING OF TITANIUM ALUMINIDE AND TITANIUM ALLOY FOIL

CONTRACT NUMBER: PRDA-91-06

STATEMENT OF NEED

Metallic foils are key components in metal matrix composites (MMCs). MMCs based on titanium and silicon carbide fibers are applicable for many high temperature structural applications in airframes, engines and missiles. Continuous fiber MMCs offer significant advantages to designers of these systems. These materials offer high strength, high creep resistance at temperature, along with tailorable properties. The advantages of MMCs will allow construction of much lower weight engine and airframe components, resulting in higher performance aircraft, and more fuel efficient engines. MMCs are an enabling technology for future hypersonic aircraft.

The objective of this program is to establish and implement processing methods for titanium aluminide and titanium alloy foil that reduce cost, reduce lead time, improve quality, and increase yield. At present, high strength foil for use as the matrix material in titanium matrix composites (TMCs) is a major contributor to the high cost of these composites. These foils are presently produced by a labor-intensive, low-yield process. This program will address the manufacturing issues for foil, producing them by an innovative, flexible and cost effective press. The result will be lower cost TMCs, allowing broader use of these high specific strength and stiffness materials in aerospace systems.

APPROACH

This program will be conducted in three phases. Phase I is the Plasma Spray (PS) preform development. The contractor will procure a minimum of forty (40) pounds of each of three titanium alloy classes (near-alpha, alpha-beta, and alpha-2) of Plasma Rotating Electrode Process (PREP) powders. This process will determine and verify the most optimal processing conditions for the process. Phase II is the scale-up demonstration of 14" wide PS preforms. Six 14" x 0.020" x 96" foil preforms will be fabricated of near-alpha alloy and alpha-2 type titanium aluminide, using the processing parameters determined in Phase I. Phase III is the production of 26" wide alpha-2 PS preforms. The contractor will scale-up the 14" wide PS preform process to fabricate 26" wide PS preforms of alpha-2 titanium aluminide.

BENEFITS

The benefits of this program are to establish and implement processing methods for titanium aluminide and titanium alloy foil that reduce cost, reduce lead time, improve quality, and increase yield. The result will be lower cost TMCs, allowing broader use of these high specific strength and stiffness materials in aerospace systems.

STATUS

New Start
Start Date - September 1991
End Date - September 1994

RESOURCES

Project Engineer: Capt. William Cameron
WL/MTPM (513) 255-5037
Contractor: TBD

CLEAN INGOT MANUFACTURING TECHNOLOGY FOR SUPERALLOY TURBINE COMPONENT

CONTRACT NUMBER: F33615-83-C-5068

STATEMENT OF NEED

The growing use of the retirement-for-cause engine disk management approach provides significant benefits associated with building a more life-cycle cost effective engine disk. Increasing its lifespan through improved manufacturing methods, even at a greater acquisition cost, can favorably effect the overall cost of the disk. Low cycle fatigue (LCF) capability relates directly to the cycles for crack initiation in engine disks, and nonmetallic oxide inclusions play a dominant role in governing the fatigue capability of high strength powder metallurgy superalloys. A large increase in disk life is achievable by decreasing the size of inclusions. This effort was pursued under contract F33615-79-C-5006, "Manufacturing Technology for Improved Quality Remelt Stock for Powder Atomization", and this contract was established as a follow-on effort to identify the effect on fatigue properties using such super-clean material.

The objective of this initial program was to identify an electron beam melt practice for the superalloy MERL 76 which would reduce nonmetallic inclusion content to 0.2 parts per million (ppm) and eliminate inclusions larger than one mil. Primary factors influencing the selection of electron beam hearth refining were: 1) absence of sources for ceramic contamination, 2) high vacuum atmosphere, 3) capability of incorporating mechanical skimmer dam and 4) availability of production scale facilities.

APPROACH

The approach was to produce clean powder from electron beam refined ingot stock with a nonmetallic inclusion content of less than 0.2 parts per million. Because of technical difficulties associated with the clean powder process, the process was modified to make disks instead by a fine grain ingot processing approach. Gas turbine engine disk shapes were then produced from this material and mechanical property testing conducted to quantify any improvement in fatigue life capabilities as a result of improved material cleanliness. The program was divided into five tasks: (1) Electron beam refinement of IN100 starting material; (2) Fine grain size ingot preparation; (3) Processing of ingots into disk forgings; (4) Mechanical property evaluation; and (5) Cost analysis.

The program resulted in the successful processing of 20 disks in three configurations weighing from 18 to 85 pounds. Mechanical property testing showed that this material exhibited slightly lower tensile, increased stress-rupture, and approximately equal LCF capability compared to powder processed IN100.

However, LCF cycles were not limited by oxide inclusions, but rather by either machining or unexpected Zr-S and Mo-B phase formation. This suggests that LCF improvements are still achievable with clean material if these other factors are controlled through alloy chemistry modifications and machining controls.

BENEFITS

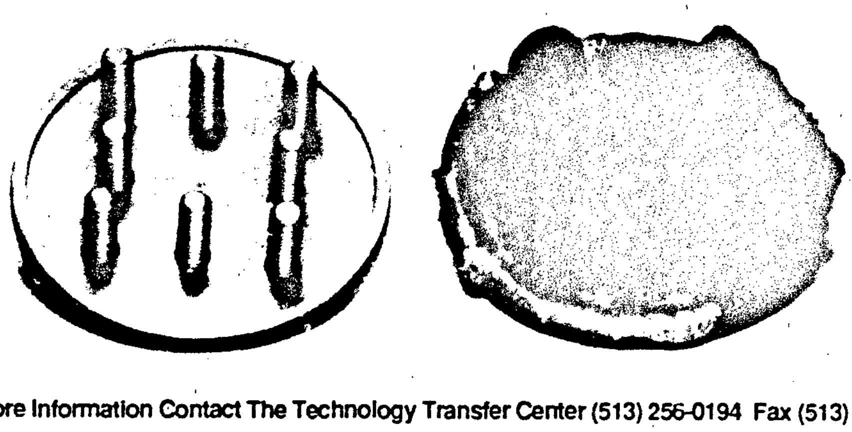
A cost analysis showed that the processing approach used in this program would cost nearly 50 percent more than powder pressing in the near term, but up to 20 percent less in the long term.

STATUS

Complete
Start Date - October 1983
End Date - August 1988
Final Technical Report : AFWAL-TR-89-8007

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: United Technologies Corp. / Pratt & Whitney



PREMIUM QUALITY TITANIUM ALLOY DISKS

CONTRACT NUMBER: F33615-88-C-5418

STATEMENT OF NEED

Methods used to produce titanium sponge, electrodes, and ingots for the manufacture of forged titanium compressor disks can result in the formation of material defects which can cause premature failure. Disk failures attributable to these defects have occurred in several engines. Engine manufacturers have worked with vendors to reduce these flaws by improving processing procedures and tightening inspection limits. This approach has reduced the occurrence of these defects but at an increased inspection cost and higher scrap rate. Improved melting techniques are required to eliminate this class of defects.

The objective of this program is to establish new processes and procedures for preparation of premium quality titanium alloys for gas turbine engine rotating components, which are significantly free of type I (hard alpha) defects while retaining freedom from type II defects and high density inclusions (HDI). The specific purpose of the effort is to provide improvements in cleanliness which will minimize the potential for random disk failure and reduce component life cycle costs in military gas turbine engines. In addition, a limited effort shall be devoted to applying/tailoring appropriate nondestructive testing equipment and techniques to consistantly detect type I defects. The result will be a verified process for the manufacturing of premium quality titanium alloys used in Air Force gas turbine engines.

APPROACH

This program was comprised of two major technical phases. Phase I w. a pilot plant scale effort which established new and novel procedures and melting for manufacturing rotor quality titanium alloys to eliminate type I (hard alpha) defects, as well as continuing to remove HDIs and type II defects. This phase also established procedures for verifying that the defects have been removed. Phase II scaled-up the processes evaluated in Phase I to standard commercial practice levels used on production equipment. Following process validation for production material, appropriate specifications are to be developed and documented.

BENEFITS

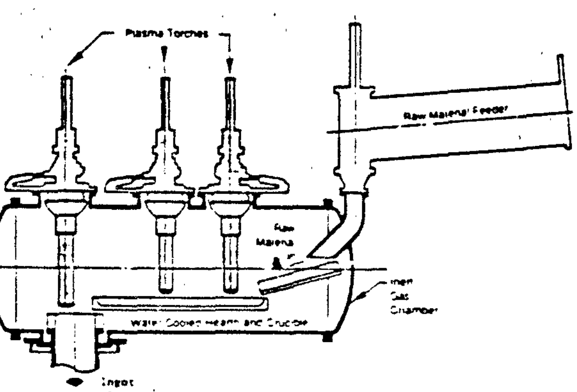
The primary benefit of reducing the number of defects will be increased titanium disk reliability. The inspection costs will also be reduced because of fewer defects and less re-inspection time. Improved melting techniques will reduce the ingot scrap rate and new processes will reduce the number of melting steps, thus reducing the final cost of the material.

STATUS

Active
Start Date - June 1987
End Date - May 1992

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM (513) 255-5037
Contractor: General Electric Company / Aircraft Business Group



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

METALS

ADVANCED MACHINING SYSTEM

CONTRACT NUMBER: F33615-83-C-5079

STATEMENT OF NEED

The overall Advanced Machining System (AMS) program objective is development of automated computer-integrated manufacturing processes to reduce aircraft production costs and significantly improve manufacturing productivity. Achievement of this objective is essential to ensure a competitive edge is maintained by the aircraft industry in the United States and to continue international fighter industry domination into the 1990s and beyond.

This factory-of-the-future objective was achieved through development and implementation of AMS concepts geared toward automated production in an unmanned, computer-based, paperless environment. Major components of this environment are the Integrated Manufacturing System (IMS), a multifaceted set of systems integrated through a common database, the Flexible Machining System (FMS), an automated machining and inspection system; and robotic technologies, including two load/unload robots and a tooling tab removal station.

APPROACH

Designed as a commercially available automated machining system, the FMS is comprised of (1) six five-axis computer numerical control (CNC) machining centers capable of unmanned operation, (2) an automated material-handling system, (3) two coordinate measuring machines (CMM's) with conventional touch probe and electro-optical measurement capabilities, (4) an Automated Storage and Retrieval System (AS/RS), (5) a robotic load/unload station, (6) chip-handling and coolant delivery systems, (7) emerging technology development to enhance FMS automation, and (8) the FMS controller, a software system to control all facets of operation, including scheduling, data management and engineering functions.

The Flexible Machining System installed on the factory floor schedules part production and produces five-axis aircraft parts in 80 different configurations without human intervention. This FMS is the first system of its kind to use distributed computer processing to distribute and update manufacturing data, to employ artificial intelligence techniques for scheduling, and to automatically control all activities.

IMS integrates product definition data (PDD), including engineering, numerical control (NC) part manufacturing programs, and manufacturing process plans, with a computerized shop floor control process and manufacturing management system capable of providing schedule, capacity, and manufacturing resource requirements data. These integrated data links provide an environment with little or no human intervention required from engineering release to shop floor process completion.

Development of IMS involved extensive investigation of existing shop floor, engineering, and manufacturing management functions, and creation or expansion of the following systems: (1) Product Definition (PD), (2) Integrated Standardized Planning (ISP) II, (3) Automated Numerical Control (ANC), (4) Shop Floor Control System (SFCS), (5) Integrated Manufacturing Database System (IMDBS), and (6) Quality Control System (QCS).

BENEFITS

All major manufacturing functions, from design to the shop floor, were automated and demonstrated during the AMS program.

The benefits are:

- Reduction in production span time, inventory requirements, direct and indirect labor, and component production costs
- Reduction of lead time required to prepare for production of future aircraft
- Establishment of a direct link between engineering and shop floor functions
- Integration of technical and managment information required to manage and control production.

STATUS

Complete
Start Date - September 1984
End Date - September 1986
Final Technical Report: AFWAL-TR-88-4173

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-2413
Contractor: General Dynamics

MACHINING INITIATIVES FOR AEROSPACE SUBCONTRACTORS (MIAS)

STATEMENT OF NEED

CONTRACT NUMBER: F33615-86-C-5010

Small machine shops produce an estimated 60% of the pieces and parts for Air Force weapon systems. They live in a period of dwindling U.S. manufacutirng capability, in an environment of dwindling master machinists, and where highly trained individuals are difficult for them to hire and to keep. At the same time, the technology developers, the companies which produce the computers, the machine tools and the other products for manufacturers, tend to aim their marketing (and therefore R&D) at the Fortune 500 or 1,000 companies. The technologies and new products are not addressed to the small shops.

This project evolved from the Air Force's concern for its small manufacturer or third and fourth tier industrial base. This consists of machine shops of, typically, 150 employees or less. The concerns have to do with the ability to mobilize or surge, the ability to acquire parts, especially repair parts, on this side of the oceans, and to develop and keep low-cost, fast-response, high quality suppliers. The Air Force needs local suppliers to work with as the technologies evolve with tighter tolerance, tougher materials, higher temperature materials and more difficult shapes.

APPROACH

A two-year study of the subcontractors' environment was performed by Air Force Manufacturing Technology people with assistance from Metcut Research Associates, using visits, polls and workshops. They sought to learn what technologies were needed, how well small shops could absorb and actually use the new technologies, and which technologies were most ready for transfer to this community.

A project was designed using technology companies, in whose best interest it would later be to transfer these technologies on a commercial basis, to demonstrate the technical feasibility of these technologies, to validate the functions and the economics, and to leave the commercial infrastructure in place at the end of the project. A communications forum was provided with an Industrial Review Board and invitations to address relevant conferences, such as the Manufacturing Technology Advisory Group/ Industrial Modernization Incentives Program (MTAG/IMIP) and RepTech conferences. Also built into the project was in Initiative specifically dedicated to technology transfer.

Three major initiatives were selected for this project: to modernize the manufacturing process, to modernize factory control, and to develop an effective modernization service.

To "modernize the manufacturing process", is to implement unattended machining workstations. Two unattended workstations were implemented: a Milacron T-30 Horizontal Machining Center and a Milacron Cintrun 1212 Horizontal Turning Center.

The second initiative, to modernize factory control, is the Management Planning and Control System (MPCS). The objective here was to establish a user-friendly system which can be tailored to the needs of the machining contractor. The MPCS consists of six modules: Quote and Order Processing, Process Planning, Shop Floor Control, Resource Control, Production scheduling, and a Financial Interface (to a standard, off-the-shelf financial package).

The third initiative is the Small Manufacturer' Improvement Service (SMIS). Specifically, it is an Air Force-sponsored modernization program which provides affordable consulting to improve the performance of small manufacturers. It seeks to optimize the current facility by improving quality, reducing costs, reducing lead times, and expanding markets. It also seeks to focus strategic planning, introduce affordable technology in an incremental manner, and justify the investments.

BENEFITS

A variety of benefits are to be gained in the MIAS program. Unattended machining and unattended turning demonstrated a 41.9% and a 30.5% cost per spindle hour respectively. The MPCS software is currently available and was estimated to have an internal rate of return of 34%. The SMIS methodologies can be used by organizations for low cost modernization consulting. The overall result is a set of technologies that can be applied to almost any discrete part subcontractor for improvements towards increased competitiveness.

STATUS

Active
Start Date - January 1986
End Date - June 1992

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513)255-2413
Contractor: Dravo Automation Sciences, Inc.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

METALS

NATIONAL CENTER FOR MANUFACTURING SCIENCE (NCMS)

CONTRACT NUMBER: F33615-91-C-5717

STATEMENT OF NEED

The NCMS is a newly formed not-for-profit research consortium of U.S. manufacturers, organized under the 1984 National Cooperative Research Act. It is designed to fund manufacturing research projects that will meet the needs of U.S. industry, including the U.S. machine tool industry, and promote the use of new technology in U.S. manufacturing companies. A major objective of the NCMS is to provide a focus for the cooperative efforts within industry to establish a research agenda to address the manufacturing needs of the United States industries in a global economy. This agenda is based on the stated needs of the member companies and is organized as a series of topical areas that encompass individual manufacturing research and development projects. These projects are to be executed through a combination of private, state, and federal funds.

APPROACH

The NCMS was established to strengthen the manufacturing community by bringing the suppliers of process technology together with their customers. In addition, the NCMS seeks to ensure a close working relationship between the private and public sectors in addressing U.S. manufacturing needs. As a private sector organization, supported by the dues of its members, NCMS seeks to instill a sense of responsibility within the private sector to take charge of its own destiny in a competitive world economy. However, as a recipient of both state and federal funds as well as being a not-for-profit corporation, NCMS must also ensure a research and action agenda which will best serve the national interest. Federal grant funds have been allocated to the NCMS by congress. These funds, once they are a part of the DoD appropriations, are administered by U.S. Air Force. It is the objective of both the Air Force and the NCMS to achieve a process which is administratively efficient, and which ensures that grant funds are used for research programs that are of high interest to U.S. industry.

BENEFITS

The benefit of this program is the promotion of research and technology transfer in manufacturing engineering in the U.S., thus decreasing our dependency on foreign durable goods.

STATUS

Active
Start Date - March 1988
End Date - December 1991

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-2413
Contractor: NCMS

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MACHINE TOOL INITIATIVE

STATEMENT OF NEED

Machine tools form the heart of modern manufacturing. The machine tool industry of a nation must be strong in order for a country's manufacturing base to compete in rapidly changing world markets. As a result of a lack of resources as well as other factors, the U.S. machine tool industry is shrinking, and imports now supply about half of the machine tools purchased for use in the U.S.

The relationship between the Air Force and the machine tool industry continues to be strong. Innovative approaches to advanced machine tool products and to the manufacturing activities employed to produce machine tools are being explored in programs directly associated with machine tool builders.

This project was aimed at revitalizing the U.S. machine tool industry. Creative ideas were sought for improving, integrating, or combining the processes used in the design, planning, production, or test of machine tools and new machine tool products. Ten contracts, varying in duration from 6 to 24 months, were awarded in FY89 and FY90. These contracts are discussed briefly below.

Advanced Grinding Machine Initiative
Contract Number: F33615-89-C-5720

The objective of this initiative was to produce the necessary research and plans to design an advanced external cylindrical grinding machine specifically for use with cubic boron nitride (CBN) wheels.

The program approach was to produce a 250 m/s (0.75 mach) external cylindrical shoe centerless machine using a cubic boron nitride (CBN) wheel for the machining of fully hardened bearing rings. This program combined the machine tool experience of Bryant Grinder Corporation and Cincinnati Milacron, the application experience of Torrington Bearings, and the analytical skills and resources of the Center for Grinding Research and Development at the University of Connecticut.

The benefits of this program show that a 250 m/second. CBN cylindrical grinder can be built with existing technology. The grinding machine specifically designed for CBN will also help U.S. grinding machine producers.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: University of Connecticut
Status: Complete - March 1991

Development of New Technology for Enhancing the Performance of the Coordinate Measuring Machine (CMM)
Contract Number: F33615-89-C-5716

This program's objective is to develop new technologies for enhancing CMMs. Techniques for on-line simultaneous measurement of multiple components of machine geometric errors, a retrofitable error compensation technique to improve the accuracy of existing electronically precompensated CMMs, and on-line error compensation methods for the enhancement of CMM accuracy at greatly increased throughput.

The approach will be to develop an on-line measurement technique for CMMs; software development for on-line error measurements; feasibility study of developing a retrofit package for CMMs; complete design and modification of a laser optically system for CMM geometric error measurement; and a prototype on-line error measurement device for CMMs.

The benefits of this program include reduction in the cost of CMMs and an increase in the performance of U.S. made CMMs.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: University of Michigan
Status: Active
Start Date - September 1989
End Date - March 1992

MACHINE TOOL INITIATIVE (cont)

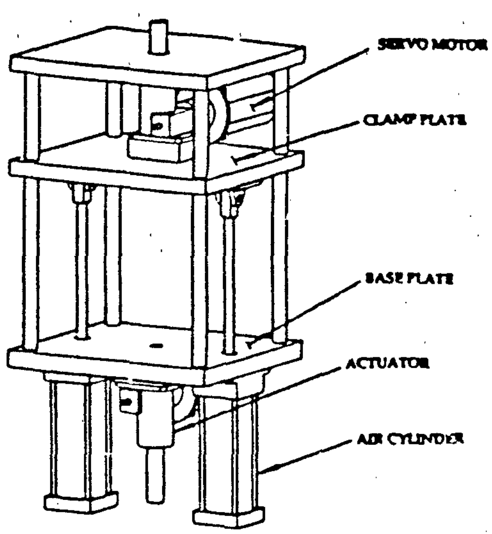
Flexible Servomotor Driven Press Computer Controlled Precision
Contract Number: F33615-89-C-5728

The objective of this program was to design a gantry machining system with affordable level of flexibility, capability, and accuracy.

Ohio State University developed a multi-action press with multiple dies and punches that are precisely controlled with servomotors. This type of press can be used to form parts conventionally made by split die, hot dies, and isothermal techniques. An increased need exists to use multi-action (split-die) techniques for precision automotive and aerospace forgings with complex geometries.

The benefits of this program include forming parts with complex geometries and reducing production costs.

Project Engineer: Stacey Rickles
WL/MTPM(513)255-3612
Contractor: Ohio State University
Status: Complete - June 1991



Signature Analysis for Processes
Contract Number: F33615-89-C-5722

The objective of this project was to develop and test signature analysis as a method for defect identification in pressing and forming operations.

The approach used was to apply signature analysis to defect identification in metal forming manufacturing. Signature Analysis applies statistical pattern recognition techniques to dynamic force measurements of the metal forming operation. Instances of good and known defects are collected as a training set. Process defects like chipped punches, press stroke changes, and material changes can be evident in dynamic force traces. The signature analysis system then learns the relationship between the selected features and the existence of the defect. This relationship can then be utilized to test for the existence of defects in future process operations.

The benefits of this program include higher accuracy of formed parts, lower scrap rates, lower labor costs and higher productivity. An assembly verification signature analysis system that can be adapted for use in metal forming will be developed.

Project Engineer: Stacey Rickles
WL/MTPM(513)255-3612
Contractor: Industrial Technology Institute
Status: Complete - March 1991

MACHINE TOOL INITIATIVE (cont)

METALS

Ultrasonic Sensing for In-Process Control of Turning
Contract Number: F33615-89-C-5729

The objective of this program was to establish and demonstrate prototype hardware and control software of surface layer removal, roughness improvement and edge finishing; on complex components using ultrasonic machining techniques.

The Mechanical Technology Institute has developed a product for the in-process control of turning or grinding operations using an on-machine measurement system based on ultrasonic technology. The program will addressed the open architecture issues involved in the interconnection of third-party subsystems having a standard machine tool controller.

The benefits of this program will be the development of a process for automatable, repeatable, uniform polishing with no chemical or electrical alterations in the surface. The process will be applicable to a wide range of material, including ceramics, composites, new alloys and plastics, with a level of accuracy not previously achievable.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: Mechanical Technology Inc.
Status: Complete - July 1990

Gantry Machining System
Contract Number: F33615-89-C-5727

The objective of this program was to develop a multi-action press of innovative design that has multiple dies that punches and that is precision-controlled with servomotors.

The approach was the use of a press that could form parts with complex geometries, using die and punch motions that are precisely controlled. A prototype unit was developed.

The benefits of this program are a 50% reduction in set-up time a 50% improvement in part quality, and a 50% reduction in scrap.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: RD&D Corporation
Status: Complete
Start Date - September 1989
End Date - March 1991

Increased Machine Tool Productivity with High Pressure Cryogenic Coolant
Contract Number: F33615-89-C-5730

The objective of this program is to validate, justify, and implement a new machining technology; a High Pressure Cryogenic Coolant Flow delivery system.

The approach will be to validate the technology by developing machining performance data and performing an engineering value analysis; integration of the Flowjet system with the mechanical and control systems of a CNC lathe; and industrial implementation, during which the Flowjet-equipped CNC lathe will be installed as a working production system, machining actual components used in Air Force weapon systems.

The benefits of this program include improving surface finish and tool life by a factor of 2-9, increasing metal removal rates by 200%, and providing unattended chip control.

Project Engineer: Siamack Mazdiyasni
WL/MTPM(513)255-3612
Contractor: Institute of Advanced Manufacturing Sciences (IAMS)
Status: Active
Start Date - September 1989
End Date - March 1992

MACHINE TOOL INITIATIVE (cont)

Ultrasonic Finishing System
Contract Number: F33615-89-C-5721

The objective of this program is to develop hardware and software for automatic close tolerance control of the finishing on complex components.

Extrude Hone is building a prototype system to optimize and demonstrate a process for the automatic control finishing of complex shapes. The process will use high frequency (ultrasonic) vibrations of an abradable tool which automatically conforms to the workpiece and to abrasive slurry for surface and sludge finish.

The benefits of this program include consistency in repeatable finish and new U.S. machining processes.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: Extrude Hone Corporation
Status: Active
Start Date - August 1989
End Date - January 1992

Highly Stable High Speed Power Spindle Head
Contract Number: F33615-89-C-5718

The objective of this program was to develop "test models" of the spindle itself and of the spindle speed control system using an innovative concept of combining the two devices. This method will provide a solution to the chatter problem which is the main obstacle to successful high-speed milling.

An optimally stiff 27,000 rpm motorized spindle, with hybrid ceramic ball bearings was developed in combination with a Digital Signal Processor-based chatter avoidance system that automatically regulates spindle speeds. Various low-overhang tooling designs were investigated.

The benefits of this program include increasing the metal removal rate by 50% and improving part quality.

Project Engineer: Stacey Rickles
WL/MTPM(513)255-3612
Contractor: TBM Setco, Incorporated
Status: Complete - May 1991

Intelligent Distributed Measurement System (IDMS)
Contract Number: F33615-89-C-5719

The objective of this program is to implement an IDMS, a sensor network designed to provide real-time sensor feedback which can be used in support of process control.

The approach will be to investigate commercially available serial communications systems, selecting one of these systems, then building and implementing a test system. Interface hardware and software will be designed for both the sensor and controller communication link. The system will be tested in conjunction with a robotic two-axis test set.

The benefits of this program include reduction of wire quantity and electrical connections, and reducing manufacturing costs by up to 90% through time savings, increased reliability and product quality.

Project Engineer: Capt. Paul Sampson
WL/MTPM(513)255-2413
Contractor: Cincinnati Milacron
Status: Active
Start Date - September 1990
End Date - March 1993

20 mm FRANGIBLE PROJECTILE

CONTRACT NUMBER: F33615-81-C-5142

METALS

STATEMENT OF NEED

The 20mm gun system, which has been the standard caliber for both the M39 and M61 aircraft cannons, uses a machined steel Target Practice (TP) projectile. This projectile presents a danger to the deploying aircraft. Numerous instances of ricocheting projectile fragments striking the delivery aircraft have occurred during aircrew training missions on air-to-ground gunnery ranges.

Both the Air Force Armament Test Laboratory at Eglin AFB and the Materials Directorate (WL/ML) at Wright Patterson AFB have performed development work on frangible projectile designs. WL/ML successfully demonstrated a powder metallurgy approach with the GAU/8A 30mm TP projectile. The objective was to achieve projectile break-up into small particles on impact, thus minimizing the possible damage from ricochets during air-to-ground firing.

The objective of this program was to establish manufacturing methods for the production of low cost 20mm target practice projectiles for the M61 and/or M39 gun system(s) that will, upon impacting a ground target, exhibit nonricochet or frangible characteristics by producing fragments of a size and configuration that have nonlethal trajectories.

APPROACH

The approach of this program consisted of two phases. In Phase I, Design/Process Verification, design concepts were established and analytically evaluated for physical and functional compatibility with the M69 and/or M39 gun system(s). Two design configurations were selected and evaluated against candidate manufacturing processes. The final baseline design selection was driven by the process that offered the greatest reproducibility at the lowest possible cost. Projectiles were fabricated and subjected to gun tests to verify that the design and manufacturing process could satisfy nonricochet TP projectile requirements.

In Phase II, Prequalification, a production plant facility was used to produce a minimum of 10,000 projectiles to establish the reproducibility of the design and process. In process nondestructive inspection techniques were investigated. Eleven hundred projectiles were selected at random and Loaded, Assembled, Packed (LAP'ed) at a Government owned contractor operated (GOCO) facility. Additional gun tests were conducted using the production plant fabricated rounds.

RESOURCES

Project Engineer: Capt. Paul Sampson
WL/MTPM (513) 255-2413
Contractor: Textron, Inc./ Avco Corporation

BENEFITS

Production of powder metal projectiles with existing production line equipment was successfully demonstrated. This was also demonstrated for nose cap fabrication and assembly, projectile machining, spin band attachment, projectile painting and marking, and final assembly to the standard cartridge case. The ballistics, structural integrity and accuracy of performance of more than 500 projectiles was excellent, with the exception of one round failing structurally.

Ricochet tests and fragment trajectory projections showed a 75-percent reduction in fragment downrange travel and a nearly 85-percent reduction in altitude compared to the standard 20mm target practice projectile (M55A2).

The test data has established that fabrication with a conventional powder metal die press is a viable approach to preventing ricocheting fragments from striking the delivery aircraft during target practice scenarios.

STATUS

Complete
Start Date - July 1979
End Date - February 1988
Final Technical Report: AFWAL-TR-88-4172

FLEXIBLE AUTOMATED WELDING FOR SINGLE CRYSTAL (SC) & DIRECTIONALLY SOLIDIFIED (DS) BLADE TIP REPAIR

CONTRACT NUMBER: N/A

STATEMENT OF NEED

Stringent mission requirements have resulted in engine manufacturers utilizing advanced superalloys in novel airfoil configurations. These advanced alloys typically have limited weldability. The current repair techniques consist of rebuilding worn blades primarily through manual welding operations. Current manual repair methods do not have the repeatability to produce a cost effective repair. A Flexible Automated Welding Machine (FAWM) will meet the requirement to weld current repair blades as well as projected future repair blades.

The objective of this jointly funded, Air Force Manufacturing Technology Directorate and Naval Air Systems Command program is to establish advanced manufacturing technology for cost effective semi-to-automatic repair processes for selected Air Force and Navy high performance gas turbine engine components. The Naval Aviation Depots and Air Logistics Centers currently are performing component repair using labor intensive manual processes that are sometimes ineffective or have high rejection rates. The manufacturing technologies to be established are for flexible automated welding of high pressure turbine (HPT) blade tip repair.

APPROACH

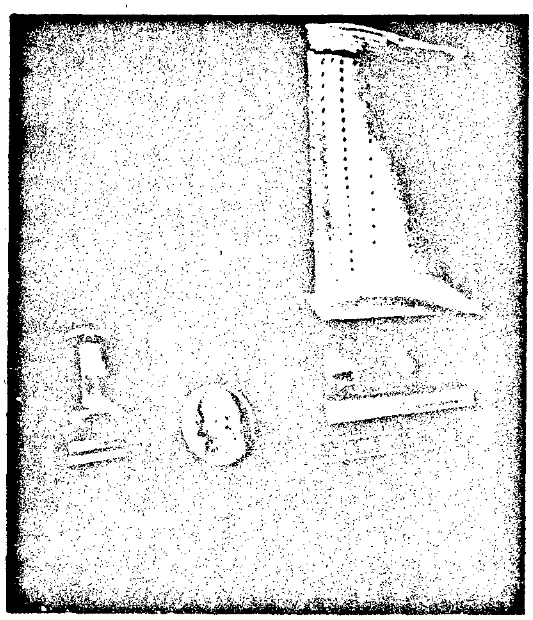
The first goal to this effort is to develop, for Navy implementation, a FAM with the flexibility to repair a wide variety of Navy and Air Force gas turbine engine components. The machinewill be flexible in design to accept the size and variety of the types of blades identified and to accept the different forms of filters, e.g. wire, powder, etc., for any deposition processes required. The machine will then be fabricated, validated, installed, and revalidated at the Cherry Point Naval Aviation Depot.

The second goal is to use the FAM design and establish, for AF Air Logistics Center implementation, an automated blade tip repair cell for gas turbine engine non-shrouded blade components. The AF welding machine will have the flexibility to handle engine components similar to the Navy components. This effort will establish a semi-to-automatic repair cell that will increase flexibility, improve efficiency and safety, and reduce repair costs relative to manual processes.

The cell will incorporate the following characteristics: inspection, preparation/finishing, deposition processes, cap restoration, cooling hole restoration, cooling hole airflow measurements, vision and measurement. The blade tip repair system cell will then be fabricated, validated, installed, and revalidated at the Oklahoma City Air Logistics Center (OC-ALC).

BENEFITS

- Reduced scrap by 30%.
- Reduced cost of blade and blade tip overhaul
- New capability to process thin walled hardware



STATUS

New Start
Start Date - March 1992
End Date - December 1995

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-3612
Contractor: TBD

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MACHINE TOOL PRODUCTS AND PROCESSES

STATEMENT OF NEED

The primary goal of this effort is to develop advanced sensory systems to improve domestic machine tools. Programs were solicited in six application areas: 1) sensor systems for precision enhancement through compensation for thermal distortion, 2) in-piece tool sensors to correct and control the manufacturing processes, 3) multiple sensors and multiple sensor technology with appropriate signal processing for process control, 4) non-contact gaging in process environments that include chips and coolant, 5) improved sensing for surface location and surface roughness, and 6) sensor systems for the measurement and characterization of machine tool performance (qualification, verification).

The objective of this effort is to improve domestic machine tool products for competition with non-domestic suppliers in product performance, quality, reliability and price.

Six contracts were awarded as a result of PRDA 90-08 PMRR, Machine Tool Sensor Improvements. Each of these are briefly discussed below.

Non-Contact Laser Profile Gauge (NCLPG)
Contract Number: F33615-91-C-5702

The objective of this program is to enable effective on-machine non-contact inspection of complex and contoured parts.

The approach will be to develop a non-contact laser profile gauge (NCLPG) that uses solid-state laser sensors designed for range, standoff, resolution, speed and environmental factors.

The benefits will be reduced part lead times; reduced scrap, rework, and repair; and improved process control.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Chesapeake Laser Systems
Status: Active, February 1991 - October 1992

Real-Time Condition Monitoring
Contract Number: F33615-91-C-5706

The objective of this program is to detect the onset or occurrence of tool fracture before the part being machined is affected.

The approach will be to develop and commercialize the intelligent insert, a low-cost tool condition monitoring system for CNC turning centers.

The benefits will be inexpensive tool monitoring, improved machine tool performance, and reduced scrap of high cost parts.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Fastman, Incorporated
Status: Active, March 1991 - April 1992

Tri-Beam for Turning Centers
Contract Number: F33615-91-C-5704

The objective of this program is to develop a non-contact, on-machine methods to monitor the diameter of turned parts.

The approach will be to build and test a high speed, non-contact tri-beam gage that will monitor the diameter of turned parts, be calibrated independently of the machine tool, and measure partts in moton.

The benefits will be improved process control of turning operations and reduced manufacturing.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Industrial Technology Institute
Status: Active, March 1991 - June 1993

Manufacturing Technology for Cutting Performance of Machining Centers
Contract Number: F33615-91-C-5707

The objective of this program is to monitor the cutting performance of machining centers and to use the resulting information for fast adaptive control.

The approach will be to develop a milling machine that can detect chatter and tool breakage and can feed information back to the controller for closed-loop process control.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Manufacturing Laboratories, Inc.
Status: Active, February 1991 - November 1992

MACHINE TOOL PRODUCTS AND PROCESSES (cont)

Spindle Thermal Error Characterization and Compensation
Contract Number: F33615-91-C-5709

The objective of this program is to reduce the effects of thermally induced errors on machine parts.

The approach will be to design and construct a precise, easy to use, inexpensive spindle error characterization and compensation system.

The benefits of this program will be reduced scrap, rework, and repair; and improved process control.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Automated Precision
Status: Active, April 1991 - March 1993

Dimensional & Surface Profile Measurement
Contract Number: F3361-91-C-5705

The objective of this program is to develop and demonstrate the use of a Capacitance Sensor Array Dimensional Inspection cell.

The contractor will develop and demonstrate a system to check and quantify dimensional information about complex workpiece shapes in a process environment on an automated machine tool. By building a capacitance sensor and then scanning the workpiece, valuable information will be obtained about the surface under the sensor(s). This data will then be assimilated, translated, and transferred to the machining press controller for setup or corrective action. Since the cost per capacitance sensor is low and processing time is short, full form verification will be done quickly and inexpensively. Careful design and integration will permit the new measurement system to be installed in or near the process being scanned.

The benefits of this program will be improved process control; reduced scrap, rework, and repair; reduced manufacturing time; and reduced labor cost.

Project Engineer: Linda Sny
WL/MTPM (513) 255-2413
Contractor: Extrude Hone Corporation
Status: Active, March 1991 - July 1993

FLEXIBLE REPAIR CENTER

CONTRACT NUMBER: F33615-86-C-5001

STATEMENT OF NEED

The repair of engine casings represents a major problem in the Oklahoma City engine repair facility. Each casing presents unique challenges and, in the current manual environment, operations are infinitely variable. Whereas engineering information exists to guide the repairs performed on engine casings, final decisions rest with machine operators, whose variable experience results in inconsistent repair procedures. Also, no formal shop floor repair and scheduling system exists to manage material flow. The shop floor is controlled by shortage lists, created to support the number of engines to be shipped each month.

The objective of this program is to develop and implement a manufacturing improvement plan for the casing repair center, utilizing computers to automate shop floor control and material processing. This plan is being executed in an evolutionary way, starting with the implementation of unattended workstations in a flexible repair center. A material handling system and an automated planning and control system are being added to support the processing equipment, resulting in an integrated manufacturing operation.

APPROACH

This program is being accomplished in multiple phases. Phase I establishes the Flexible Repair Center (FRC) needs, requirements, system specification and system design specification. Phase II establishes the product specification, and builds and tests the subsystems comprising the FRC. Phase III will integrate the subsystems. Phase IV will validate the production capability.

The program is using the typical life cycle approach to identify the problems to be solved, to determine alternate solutions, to select the best solution, and then to implement that solution. An inspection driven repair operations planning system will be implemented based upon macro programming modules that define features to be repaired in the casing. The shop floor control system will manage the flow of materials, tools and fixtures, in both the FRC and in the casing repair center. Finally, unattended workstations will be utilized as a flexible machining system by the inclusion of an automatically guided vehicle material handling system. The workstations will include automatic load/unload resources, Computer Numerical Control (CNC), and in process measurement adaptive control.

BENEFITS

Benefits will include production management of systems to effectively control operations on the floor and query capability as to the location and repair status of the cases in the FRC. The systems are being designed to incorporate such features as user friendly interfaces to the system, expansion capabilities and interfaces with existing and planned production management systems at the Oklahoma City-Air Logistics Center (OC-ALC).

STATUS

Active
Start Date - July 1986
End Date - December 1992

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Dravo Automation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

METALS

ISOTHERMAL SHEET ROLLING

CONTRACT NUMBER: F33615-85-C-5131

STATEMENT OF NEED

The concept of electrical resistance heating of metals, in order to deform or join them, is a very old idea. Heating of wire and bar prior to rolling or bending and the flash-butt welding of bars into rings are two typical examples of this concept that have been used for more than 50 years. Spot and seam welding of similar and dissimilar metals has also become widely used as a low cost joining technique for many applications. From these joining processes came the technical understanding that electrical current through the interface between metals generates most of the heat at the interface because the electrical resistance is greatest at the junction. The resistance heating is a function of the material resistivity, surface condition, pressure applied, time of current application and the level of current. This joining technology spawned the concept of using interface heating to bond metals together and to roll them in thin section shapes.

As high temperature alloys evolved, conventional hot rolling and forging practices became more difficult due to the combination of greater strength and lower ductility at high temperatures. The temperature range where rolling could be done limited the amount of deformation that could be accomplished with each pass. Also, the temperature range where deformation was feasible narrowed for the stronger materials that have been developed.

The objective of this program was to establish and demonstrate a novel isothermal rolling process for the production of thin sheet stock of advanced high temperature materials for aircraft engine components and to evaluate the isothermal rolling press for producing products that have the Allison lamilloy construction.

APPROACH

This program consisted of four phases. Phase I addressed the refurbishment of the Air Force/Inco mill. Phase II involved the fabrication of both 6 inch and 12 inch wide TZM molybdenum alloy rolls; the mill shakedown focused on the use of the narrow rolls followed by a demonstration of the wider rolls near the conclusion of the program. Phase III involved process studies for rolling a variety of titanium, nickel and cobalt based alloys, as well as feasibility efforts aimed at sheet cladding and calendering of sheets for potential use in laminated diffusion bonded structures. Phase IV involved establishing a sheet production capability; it also addressed the impact of the technology on current and future military and commercial aircraft production.

BENEFITS

Overall, this program has led to an improved understanding of the technology related to the isothermal rolling process. The lessons learned from this project are proving to be extremely valuable relative to extending the concept to the emerging new classes of difficult-to-roll materials that will be required for Integrated High Performance Turbine Engine Technology (IHPTET) and National Aerospace Plane (NASP).

This technical base will be helpful in designing and building a third generation Isothermal Rolling Mill (IRM), which will be needed for the production of cost effective sheet and foil forms in advanced alloy systems. These alloy systems will be required the next generation aircraft and propulsion systems.

STATUS

Complete
Start Date - February 1986
End Date - August 1987
Final Technical Report: WRDC-TR-89-8028

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: General Motors Corporation

ND: YAG LASER CUTTING & WELDING

CONTRACT NUMBER: F33615-88-C-5435

STATEMENT OF NEED

This project is the second phase of a three phase program to establish a pulsed Nd:YAG robotic workcell for repairing jet engine components.

A wide application range exists for a Nd:YAG laser work station at the Air Logistic Centers for repair operations during maintenance on airframes and engines. The cost of the beam delivery system is a significant part of laser cut/weld/drill systems. With a Nd:YAG laser, a fiber optics beam delivery system can be used with lower initial cost, lower maintenance, and greater flexibility than with a CO_2 laser, which permits multiple work stations with alternating or multiplexed beam delivery.

APPROACH

The Phase I study assessed the feasibility of using a 400 watt average power pulsed Nd:YAG laser to repair combustion chambers from Pratt & Whitney TF30 engines. This repair involves cutting out damaged areas and replacing them with welded patches. The contractor had expenence with this application in developing a system for the Navy under Contract N00600-85-C-3185, using a 1500 watt, continuous wave CO_2 laser.

The Phase I study established the capabilities and limitations of the Nd:YAG laser for use on high strength, high temperature turbine engine materials. It was established that cutting could be accomplished on all required areas of the combustion chambers and, therefore on practically all areas to be repaired on airframes, engines, or accessories. Welding could be accomplished on most of the areas needing repair.

Phase II established a robotic system with a 400 watt average power Nd:YAG laser, a fiber optic beam delivery system, an end effector, and a three-dimensional vision system suitable for repair applications involving cutting and welding of aircraft engine and airframe parts. Phase II was a prototype effort which emphasizes a system that is versatile and easily operated. The system was characterized and validated by performing cutting and welding operations on representative parts.

Phase III will complete the system by establishing a fully functional robotic work cell suitable for implementation at the Air Logistics Centers (ALCs).

BENEFITS

The benefit of this program is a lower cost, more versatile system than a CO_2 laser system. Nd:YAG lasers will allow use of a fiber optics robotic system.

STATUS

Active
Start Date - January 1988
End Date - September 1991

RESOURCES

Project Engineer: Tim Swigart
WL/MTPM (513) 255-2413
Contractor: International Technical Associates, Inc.

METALS

COMPOSITES INSERVICE INSPECTION SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-83-C-5066

STATEMENT OF NEED

Considerable effort has been expended over the last few years to establish an inspection capability for aircraft composite and bonded structures that has manual scanning ultrasonic inspection occurring simultaneously with the automatic recording of inspection data. This effort was to establish a system that 1) is compatible with current manual inspection procedures; 2) records inspection data and produces images similar to those obtained during production testing; and 3) increases the overall efficiency of the inspection. A primary advantage of having a system that meets these requirements is the availability of permanenetly recorded data presentations to identify changes in flaw configuration and size over a period of aircraft operation.

The objective of this program also established the producibility of a field ready, lightweight, portable ultrasonic nondestructive inspection system for aircraft composite structures, including fiber-matrix laminates and/or metallic materials. It will also establish a capability for a manufacturing system to provide quantities sufficient for all anticipated future requirements of Air Force and commercial operators.

APPROACH

The approach to this program was accomplished in three phases. Phase I, the Preproduction System Design and Design Verification, included the following: evaluation of Inservice Inspection System (ISIS) prototype; drafting preliminary design of the proposed concept; verifying solutions to concept/configuration/ assemblies; and preliminary design review. Phase II, Preproduction System Fabrication and Evaluation, included the following: fabrication of a preproduction system; contractor evaluation of the preproduction system; and field evaulation. Phase III, Production System, included the following: fabrication of the production system and contractor evaluation. Phase IV, Field Evaluation and Documentation of the Production System, included the following: field evaluation of the production system, and preparation of the documentation for the production system.

The prototype system fabricated under this contract was used as a technology base. The program resulted in the delivery of four production Automated Real-Time Image System (ARIS) units and one preproduction ARIS unit.

The ARIS provides automated, simultaneous recording of ultrasonic data and search-unit position information during a manually scanned inspection of composite and bonded aircraft structures. The system is designed for easy portability, fast on-site setup, high productivity, and operation by a single operator. The operational requirements of the system are such that the operator need have only an ultrasonic nondestructive evaluation (NDE) backgroundequivalent to that normally required of an ASNT SNT-TC-LA certified Level I examiner (i.e., knowledge of basic concepts and ability to perform a calibration and other specific tasks according to written instructions). Site-support requirements for the system are limited to providing electrical-power hookup at the inspection locations on the aircraft not inspectable from ground level.

BENEFITS

The practical application of the technology was dependent on addressing the specific needs of the inspector: complexity of setup, and inspection time, flexibility, and portability. These factors were important to the success of any field inspection activity. With automated data collection features, there are the additional requirements of the system to collect, store, and process the large amounts of data in a convenient way. The convenient use of this data is the key ARIS technical benefit, as ARIS images acquired during different stages of aircraft life can be compared with each other and with production images to monitor flaw growth. The ARIS development program specifically addressed establishment of a system that is efficient in the field inspection environment.

STATUS

Complete
Start Date - February 1984
End Date - October 1988
Final Technical Report: AFWAL-TR-88-4218

RESOURCES

Project Engineer: Edward Wheeler
WL/MTPM (513) 255-7279
Contractor: System Research Laboratories

HIGH TEMPERATURE SHEET ROLLING

METALS

CONTRACT NUMBER: F33615-78-C-5072

STATEMENT OF NEED

Sheet product forms for many applications require high strength at high temperatures, accompanied by good corrosion resistance. These two material characteristics, usually achieved by compositional modifications, are difficult to obtain in a single material, as alloying to improve strength often degrades corrosion resistance. Alloy compositions are thus carefully balanced to yield a reasonable compromise of strength and corrosion resistance. Currently used sheet materials are relatively simple, vis-a-vis precipitate formations, etc., but are complexly balanced compositionally to allow sheet production.

New materials such as ODS (oxide dispersion strengthened) superalloys offer significant advantages over currently available alloys. However, they do not readily lend themselves to production by the techniques used for sheet processing at the present time. Processing difficulties have kept yields quite low, thus raising costs and limiting the use of these alloys. Alloy complexity has additional ramifications, as indicated by the sensitivity of properties to the processing schedule parameters. The development of processing techniques utilizing complex, multi-faceted schedules requires a major effort and delays the introduction of these materials to the marketplace.

The objective of this program was to provide the capability for processing higher performance, higher quality, and lower cost alloy sheets which are now commercially available.

APPROACH

The program objectives were achieved using an isothermal sheet rolling technology of recent origin that was demonstrated on a prototype mill at Solar Turbines. The mill design was developed from prototype mill studies and allowed control of workpiece and roll temperature as well as deformation rate.

The program was conducted in two phases. Phase I involved the mill design, addressed the system design and included a preliminary evaluation of rolled strips. Four high temperature alloys were used to develop the design, including two superalloys and two oxide dispersion strengthened (ODS) alloys. Each alloy was characterized both microstructurally and for flow stress as a function of temperature and strain rate. Phase II was the mill construction phase which addressed mill construction, mill shakedown, and more extensive alloy processing on the upgraded Solar prototype mill. The Solar prototype mill was modified to incorporate the design features defined in Phase I. Rolling trials performed on the Solar prototype mill demonstrated the feasibility of the isothermal rolling concept.

BENEFITS

This concept appears to be a breakthrough in high performance alloy sheet fabrication technology. Early rolling trials produced workpiece reductions of greater than 50% for short lengths.

STATUS

Complete
Start Date - February 1979
End Date - January 1984
Final Technical Report: AFWAL-TR-85-4116

RESOURCES

Project Engineer: Edward Wheeler
WL/MTPM (513) 255-2413
Contractor: Inco Research & Development Center, Inc.

METALS

ADVANCED PROPULSION MATERIALS

CONTRACT NUMBER: F33615-85-C-5014
F33615-85-C-5152

STATEMENT OF NEED

The need exists to extend the altitude and Mach number capabilities of future military fighter, interceptor, and surveillance aircraft beyond those of current systems. Meeting this need will require significant advances in aircraft propulsion system technology. Advances must be made in all areas of propulsion system design and manufacturing technology to assure that design requirements are met for future weapons systems.

Specifically, advanced aircraft propulsion systems must have very high thrust-to-weight and thrust-to-airflow ratios if the aircraft systems are to meet requirements at an affordable cost without penalties in range, fuel consumption, or payload. The high thrust-to-weight requirements for supersonic aircraft propulsion systems will require the incorporation of lightweight components of advanced materials.

The overall objective of this program is to aggressively establish cost-effective manufacturing methods for higher performance component/materials systems for the next generation fighter engines which are currently well beyond the established manufacturing technology base. This program will assure the capability to manufacture the advanced designs now evolving for high performance fighter engines components by providing the significant, cost effective manufacturing technology improvements required to incorporate these designs into production. Maintainability will be established for program components concurrently with the manufacturing methods. It is also the goal of the program to establish a vendor industrial base for full scale production of components requiring this technology.

APPROACH

Two contractors were selected to conduct the efforts under this program. Several advanced material approaches have been developed including the following:

- Titanium Integrally Bladed Rotor Fabrication - This approach will establish key Integrally Bladed Rotor (IBR) manufacturing technologies: near net shape hub forgings; hollow airfoil fabrication; blade to hub attachment; airfoil reattachment repair; Non-Destructive Evaluation (NDE) of IBR components; and IBR fabrication. Activities include component selection, integral forging of an IBR component, titanium IBR repair, NDE of titanium IBR components and engine hardware, and titanium IBR manufacturing evaluation.

- Superalloy IBR Repair - This effort consisted of two phases: minor repair methods and attachment repair methods. Minor airfoil damage repair and the removal and replacement of airfoils were also addressed. Minor airfoil repair methods for superalloy integrally bladed rotors include airfoil leading- and trailing-edge blending, airfoil tip-wear repair, and knife-edge seal welding. The repair sequence under study involves blade removal, surface preparation of the blade stub for welding, forge welding of an oversize replacement blade, and finish--machined weldment by milling or electrochemical machining.

- Carbon-Carbon Structural Applications - The baseline Carbon-Carbon (C-C) system chosen for this program included an uninhibited Advanced Carbon-Carbon (ACC) substrate designated ACC(4) and a two-part, oxidation-resistance coating, T1K2.

- Non-Destructive Evaluation - This approach consists of two phases: the preliminary evaluation of NDE methods and NDE of full-scale configurations.

- Non-Fracture-Critical Titanium Aluminides - This approach consists of three tasks. Task 1 is a demonstration of manufacturing methods for the production of rolled rings, sheets, and castings using the Ti-14A1-21Nb alloy. Task 2 is a verification of a production plan by manufacturing subcomponents. Task 3 involves the manufacture of sufficient quantities of hardware to demonstrate reproducibility and cost effectiveness.

- Carbon-Carbon Nonstructural Applications - The manufacturing methods associated with the nonstructural C-C cooling liners of an advanced two-dimensional nozzle (2-D) were to be optimized with respect to cost and reproducibility. The 2-D nozzle was being developed to provide thrust vectoring and thrust-reversing capabilities to advanced gas turbine engines to improve maneuverability and to reduce take off and landing distances.

ADVANCED PROPULSION MATERIALS (cont)

• Automated Vane Cell - This approach will establish manufacturing methods for fabricating advanced turbine engines. The contractor has developed an integrated manufacturing cell for the fabrication of composite aircraft engine vanes. All operations are automatic and controlled by a cell controller, except for the manual layup of the composite plies.

• Composite Airfoil Manufacturing for Fan Applications - Efforts conducted under this approach will establish the necessary high-volume production methods, for manufacturing advanced, high-temperature composite parts in a cost-effective manner. The inlet guide vane (IGV) flap and the first stator are currently being designed as composite parts for the F119/Advanced Tactical Fighter Engine (ATFE). The successful results obtained on these IGV flaps and 1st-stage stator vanes have prompted an extension of the use of composites further aft in the engine. One structure with a potential weight savings of more than 30 pounds is the intermediate case airfoil assembly.

• Fabricated Airfoils - This approach will establish cost-effective methods for fabricating precision gas turbine airfoils. Facility requirements will be established for a limited volume production pilot facility and defined for a full production facility. Fabricated turbine airfoils offer the promise of a significant weight reduction over cast one-piece blades with advanced internal cooling configurations, due to the precision that can be obtained by certain machining techniques. Lower individual blade weight results in less blade pull on its respective turbine rotor during operation, thus allowing disk weight to also be reduced. Increased capability through reduced weight can be used for increased thrust and/or increased service life.

• This effort was divided into five tasks. Task 1 established cost-effective processes for fabricating turbine airfoils. Task 2 defined the detailed requirements for a pilot production airfoil facility. Task 3 fabricated blades and vanes to demonstrate casting equivalent performance and quality. Task 4 establishes a pilot production airfoil facility using the requirements and designs developed in Task 2. Task 5 demonstrates the facility systems (of Task 4) through limited hardware production.

• Single Crystal Airfoil Repair - This approach was established to investigate the technologies required for the repair of F100-PW-220 single crystal alloy components. The objectives were to perform minor repairs on engine-operated F100-PW-220 hardware and make the repaired components available for engine test, and to investigate techniques for more extensive repairs.

• To accomplish these objectives, a single task, Process Definition and Demonstration, was conducted. This task included the repair of F100-PW-220 hardware which had previously been operated in experimental engines; this hardware was made available for engine testing. Damage on this hardware was minor due to the improved durability of single crystal material. Primary repairs included weld buildup of blade tips and vane platforms, vane coating removal and replacement and blade overcoating.

• Also, several innovative approaches for repairing more extensive damage in single crystal hardware were evaluated. These repair technologies were previously developed and proven feasible, and include six major areas: crack repair, blade tip restoration, rejuvenation, oxidation/erosion repair, airfoil removal and replacement, and coating removal replacement.

BENEFITS

Benefits of this program include:

- Reduced component acquisition costs
- Weight savings
- Fuel Savings
- Establishment of repair technology
- Demonstration of the production approach for the F-119 engine intermediate case

STATUS

Active
Start Date - August 1985
End Date - February 1992

RESOURCES

Project Engineer: Ken Kojola
WL/MTPM(513) 255-5037
Contractor: 1) General Electric
2) United Technologies/Pratt & Whitney

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

CHAFF COIL

CONTRACT NUMBER: F33615-87-C-5334

STATEMENT OF NEED

Decoy and chaff programs were proceeding at a satisfactory pace to enter full - scale engineering development; however, a high cost element was identified in the chaff area. The cost of the chaff was estimated to be $200M for a particular system. Approximately 75% of the chaff coil costs are in the coiling operation. Because of this, significant cost savings can be obtained by implementing an automated coiling system.

Chaff coil manufacturing was a manual operation requiring approximately 72 man-hours for each coil produced. There are currently no efficient production techniques or suitable quality control methods available to insure the manufacture of producible, low cost dispensers. The lack of a high rate, reliable manufacturing systems caused the delivery of acceptable chaff systems to lag behind system requirements. The application of automated processes to dispenser manufacturing increased the availability for system usage and improve overall quality and performance.

The objective of this program was to reduce costs and improve reliability in chaff coil production programs. The intent was to establish a low cost chaff coil forming process through the application of automated techniques to reduce hand labor and to improve the reproducibility and reliability of the coils. The process development was needed to represent a significant coiling time reduction. The development of coiling has progressed from a completely manual operation to a semi-automated process that imitates the hand-labor process. It was the purpose of this project to develop the process further into a fully automated operation.

APPROACH

The approach involved the establishment of an automated system to produce chaff coils/dispensers having increased quality. This project emphasized a high reliability and lower cost manufacturing based upon the successfully demonstrated prototype process supported by Ballistic Missile Division (BMD). The first part of the program generated the specific approaches to be incorporated into the manufacturing system. The second part of the program demonstrated the automated system by production of a specific lot of chaff coil dispensers.

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7277
Contractor: Tracor Aerospace Inc.

BENEFITS

The chaff coiling process developed under this program departs from previous auto coilers in that the entire process is an "in-line feeder". Results indicate a cost savings of over $8M per year over a two year period.

STATUS

Complete
Start Date - September 1987
End Date - May 1989
Final Technical Report: WRDC-TR-89-8042

LARGE AIRCRAFT COMPOSITE WING

CONTRACT NUMBER: F33615-83-C-5046

STATEMENT OF NEED

The application of advanced composites for the construction of aircraft structures has advanced dramatically during the past two decades. This is evidenced by projections that up to 55 percent of the structural airframe weight of the next generation of tactical and lightweight commercial aircraft will be these components. The production base for validating these projections has been almost exclusively limited to small aircraft such as the F-14, F-15, and F-16. As a result, a competent level of manufacturing capability for that type and size of aircraft has been well established.

Large aircraft applications aimed at capitalizing on the known benefits of composite structures were, up to the start of this program, limited predominantly to (1) small area components, and thin sections that are principally secondary structure in nature, and (2) the scale of manufacturing validated by the small aircraft fabrication experiences.

The overall objective of this program was to establish and validate manufacturing technologies for large aircraft composite wing structures that produce structures at a reasonable and predictable cost. This was accomplished by reviewing the most current materials, material forms, and fabrication processes; by assessing their efficient application for large aircraft wing structures; and by validating their applicability through demonstration of scale-up fabrication of selected components.

APPROACH

This program was conducted in four phases. Phase I, Manufacturing Methods Definition, consisted of identifying candidate manufacturing processes and techniques, tooling material concepts, and substructure automation techniques.

Phase II, Manufacturing Methods Verification, was structured to verify the candidate materials and manufacturing techniques by subscale specimen fabrication to provide direction for the remainder of the program. Validation was accomplished by a comparative assessment of part quality, dimensional control reproducibility, part fabrication, and tool cycling. An economic assessment of selected structures and methods was made. Materials selected for in-depth evaluation in Phase II included graphite-epoxy, graphite-bismaleimide, and graphite-thermoplastic.

In Phase III, Scale-Up/Full-Scale Demonstration, tools were designed, fabricated and proofed for 8 by 20 foot wing skins, spars, ribs, and stiffeners.

In Phase IV, Full-Scale Fabrication and Production Demonstration, the completed 20 foot covers, 12 foot spars, mid-spar, inboard closeout rib, and intermediate ribs were assembled into an 8 by 20 foot demonstration wing box by conventional jigging, drilling, and mechanical fastening methods.

BENEFITS

The successful results of this program have contributed to the use of advanced composites in future DoD/NASA aircraft and spacecraft. This program demonstrated that curing of large, thick, tapered laminates poses no risks and that large composite tooling is producible with predictable costs. No appreciable processing (curing) difference exists between thick laminates made from the most commonly used fibers/thermosets. Automated tape laying is an effective low-cost layup technique. Six-axis fiber placement is an effective method for fabricating structural shapes such as channel spars.

Thermoplastic composite feasibility investigations yielded the following conclusions: hand layup is costly and impractical for large parts, hot-head tape laying is promising, semi-automated nesting and kitting is impractical, adhesive bonding is feasible, restraint is needed to prevent fiber movement at processing temperatures, and delamination can occur after consolidation if heat is applied without pressure.

STATUS

Complete
Start Date - December 1983
End Date - January 1988
Final Technical Report: AFWAL-TR-88-4104

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7277
Contractor: Rockwell International Corporation

MANUFACTURING OF THERMOPLASTIC COMPOSITE PREFERRED SPARES

CONTRACT NUMBER: N/A

STATEMENT OF NEED

The use of advanced composites in new weapon systems has been dramatically increasing. Advanced composites enable the desired goals for range, speed, payload, and supportability to be achieved. The advantages of composite materials can be further realized by the utilization of thermoplastic materials in place of conventional thermoset materials. Thermoplastics processing characteristics permit consolidation, forming, joining and (in some cases) material placement to all occur during a reversible melt and flow of the resin with no chemical reaction taking place. This allows for reprocessing of parts and introduces many new and potentially lower cost processing approaches. The challenge lies in inserting this technology into existing DoD aircraft to realize these benefits. The goal of this effort is to enhance Air Logistics Center (ALC) design capability and to establish a repair and limited remanufacturing capability for non-flight safety critical structures (spares) utilizing thermoplastic materials.

One of the major barriers to using thermoplastic composites is the lack of knowledge concerning their processing characteristics, and the limited development and validation of low cost processing methods. There have been many efforts to utilize expert system technology to assist the designer in assimilating the necessary information for the design and manufacture of thermoplastic components. The recently completed Manufacturing Science of Complex Shape Thermoplastics, contract F33615-86-C-5008, is one such effort. Various companies have invested their own IR&D funds to attempt the same objectives. The purpose of this effort is to utilize existing thermoplastic technology by tailoring it to ALC needs for inserting non- critical components for (spares) existing DoD aircraft.

APPROACH

This program will focus on the use of computer-aided manufacturing technologies to develop and validate an integrated design/manufacturing system for non-critical thermoplastic structural components. The program will be accomplished in three phases. The first phase will consist of all activities required to define the Integrated Product Manufacturing System (IPMS). This includes system architecture, user requirements and data collection. Phase II consists of building the IPMS and validating the logic of the knowledge-base. Phase III will be the demonstration of the IPMS. This will be accomplished by identifying at least two non-flight safety critical components which exhibit supportability problems and, using the IPMS, design and manufacture the replacement items utilizing thermoplastic materials. The demonstration effort will take place at one or more ALCs. The parts identified will be from aircraft which are currently in the Air Force inventory.

BENEFITS

- Potential for lower cost processing of thermoplastics and lower cost of spares

STATUS

New Start
Start Date - September 1991
End Date - September 1995

RESOURCES

Project Engineer: Daniel Brewer
WL/MTPN (513) 255-7278
Contractor: Northrop Corporation

NONMETALS

NONMETALS

DESIGN & MANUFACTURING OF THERMOPLASTIC STRUCTURES (DMATS)

CONTRACT NUMBER: F33615-87-C-5242
F33615-87-C-5333

STATEMENT OF NEED

Many years of materials development and manufacturing experience have resulted in extensive applications of thermoset resin reinforced composites in airframe structures. Much greater use is projected for future aircraft systems. Concurrently, exploratory development on matrix materials has resulted in the availability of thermoplastic resins with mechanical, physical and damage tolerance properties which make composite materials even more attractive for airframe structure The chemistry of the thermoplastic matrix indicates potential manufacturing and production advantages such as instant cure, unlimited shelf time, and the ability to be post-formed into intricate shapes. The very limited manufacturing knowledge and experience with these materials precludes the maximum exploitation of their capabilities. Optimum fabrication processes and limits must be established to enable maximum use of these composite materials and to realize the cost and performance advantages.

The objective of this program is to establish and validate advanced designs and low cost manufacturing technologies for the production of thermoplastic structures for the next generation advanced Air Force aircraft.

APPROACH

Two phases will be accomplished. Phase I is the fabricating and testing of secondary structures. Phase II is the designing, fabricating, and testing of primary structures.

The specific thermoplastic matrix materials to be used will be selected primarily through performance factors including laminate mechanical property data, physical properties with emphasis on impact resistance, cost, and material form availability. The material handling and consolidation/fabrication methods will be scoped in a manner to be generic to a wide range of thermoplastic matrix materials for broad applications. Limits on the post-formability to typical aircraft component shapes will be established. A cost/benefits analysis for comparing thermoplastic and thermoset matrix composite structures will be provided.

BENEFITS

Reduced manufacturing and fabrication costs of composite structures are expected by using thermoplastics in place of thermoset materials. Reductions will come from shorter process cycle times and post forming of consolidated laminates to airfoil shapes using already existing metal forming techniques and equipment.

STATUS

Active
Start Date - April 1988
End Date - December 1991

RESOURCES

Project Engineer: Diana Carlin
WL/MTPN(513) 255-7277
Contractor: 1) Northrop Corporation Aircraft Division
2) Lockheed Corporation

ADVANCED COMPOSITE REPAIR CENTER (ACoRC)

CONTRACT NUMBER: F33615-86-C-5033

STATEMENT OF NEED

The Air Force Logistics Command has recognized that its present capability for repairing and maintaining advanced composite aircraft structures is limited. With the increasing use of composites in aircraft structures, there is arequirement to bring this area into balance with other repair functions.

This program was to establish a generic integrated composites repair center process and equipment layout description with the identification of facilities/equipment necessary for reliable low cost maintenance/ repair of advanced composite aircraft structures. Optimum repair techniques were to be demonstrated for a broad class of structures. Individual ALC's would select and implement the repair technologies dependent upon the weapon systems assigned.

APPROACH

Lockheed Aeronautical Systems Company (LASC), supported by nine subcontractor team members conducted the ACoRC program. This program was designed to establish and demonstrate all of the key elements necessary to provide low-cost reliable maintenance of advanced composite structures.

The program was originally proposed to be accomplished in four phases: Phase I - Detail Design; Phase II - Establish, Integrate, Implement and Validate; Phase III - Demonstration and Cost Benefits Analysis; and Phase IV - Technology Transition.

A preliminary detail design briefing was held at Sacramento ALC(SM-ALC) which included the preliminary design, layout and equipment recommendations. The Air Force decided not to proceed with Phases II and III. This decision was a result of technology advances and of changing requirements which negated the value of the results to be obtained by continuing the program as initially planned.

In Phase I, a preliminary detail design was established for SM-ALC. Consideration was given to the equipment/facilities already in place and the acquisition of equipment planned resulting from both the ACoRC study program and the Honeycomb Repair Center (HRC) program. The preliminary detail design involved those tasks and activities required to integrate a generic repair capability within the SM-ALC environment.

Phase IV, Technology Transition, ran concurrently with Phase I and provided for the transition of technology from SM-ALC/ACoRC to the other four ALCs located at Ogden ALC (Hill AFB), Oklahma City ALC (Tinker AFB, Oklahoma), Warner-Robins ALC (Robins AFB, Georgia), and San Antonio ALC (San Antonio, Texas). The transition of technology was accomplished through team meetings, monthly and quarterly progress reports, trip reports, site visits, and telephone communications.

Recommendations were made for each of the other ALCs in the form of updated Needs Analyses to reflect the current environment and updated Systems Requirement Documents to answer those needs.

BENEFITS

A number of benefits resulted from this program, including increased fabrication capacity, greater throughput, reduced lead time for developing repair planning, increased worker performance, less scrap, greater equipment reliability, and reduced testing costs.

STATUS

Complete
Start Date - October 1986
End Date - April 1989
Final Technical Report: AFWAL-TR-89-8015

RESOURCES

Project Engineer: David Beeler
WL/MTPN (513) 255-7279
Contractor: Lockheed Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

NONMETALS

LARGE AIRCRAFT FUSELAGE MANUFACTURING

CONTRACT NUMBER: F33615-83-C-5024

STATEMENT OF NEED

Advanced-composite structures are lightweight, strong, stiff, and resistant to fatigue and corrosion. These features make composites highly attractive for major applications in military and commercial aircraft. Currently, industry is producing a number of composite components for secondary structural applications, and a significant amount of R&D effort is being expended to develop engineering and manufacturing technology for expanded applications. Wing primary structures from the AV-8 and A-6 programs are in production. To maximize the benefits of using composites on aircraft, there is a need for a corresponding level of development activity on fuselage primary structures in order to improve design efficiency and reduce manufacturing cost.

This program addressed the need to establish manufacturing capability to produce primary composite fuselage structures for large aircraft at predictable and reasonable costs. The program objective was to establish and validate low cost manufacturing methods for the efficient production of these structures which could be applied to a variety of future aerospace systems. The first two phases of the program validated design concepts and fabrication techniques suitable for the fabrication of widebody transport structures. The latter phases of the program used these selected techniques and applied them to the all-composite V-22Ttiltrotor fuselage.

APPROACH

This program combined the technical skills, automation technology, resources, and production experience of six companies in a concentrated effort to achieve maximum cost-effectiveness in composite fuselage manufacturing.

The technical portion of the program was divided into four phases covering 81 months. The program phases were Phase I- Manufacturing Methods Definition, Phase II-Manufacturing Method Establishment, Phase III-1-Manufacturing Verification, and Phase III-2-Production Demonstration.

In order to evaluate various manufacturing methods and assure incorporation of the latest state-of-the-art technology in advanced-composite manufacturing, the six-member team produced manufacturing test hardware during the first two phases of the program. These test components were compared for manufacturing cost, ability, strength and weight. The methods shown to be superior were selected.

In the third and fourth phases, the optimum methods for producing skin panels and frames were used to fabricate full-size verification and demonstration hardware. After preliminary coordination and planning, the Air Force redirected the production demonstration component to the CV-22 fuselage. The phase III demonstration components consisted of a one-piece, filament-wound CV-22 aft fuselage section. A tool proof-unit and three replicates were fabricated.

BENEFITS

The successful completion of this program and the attainment of its objectives demonstrated that the industry is capable of and has the technology to produce large aircraft composite fuselage structures at costs significantly lower than those incurred in current production programs. The design, fabrication, and use of a large, complex, multipiece tow placement mandrel were demonstrated along with the development and use of a low cost, direct-impregnated carbon fiber tow. Fiber placement technology, coupled with the developed fiber tow prepreg material, was shown to produce composite structures having engineering properties equal to those produced by conventional materials and processes. Labor savings on indivudal components ranged from 53 to 60 percent.

STATUS

Complete
Start Date - November 1982
End Date - December 1989
Final Technial Report: WRDC-TR-90-8034

RESOURCES

Project Engineer: Robert Neff
WL/MTPN (513) 255-7279
Contractor: Boeing Helicopter Company

AUTOMATED FABRICATION OF SMALL ENGINE COMPOSITE COMPRESSOR ROTORS

CONTRACT NUMBER: F33615-88-C-5400

NONMETALS

STATEMENT OF NEED

Composite rotor applications are being proposed to replace cast metal rotors in limited-life missile system engines. Previous programs have demonstrated the feasibility of contiuous fiber placement. Initial cost investigations have shown that it is possible to reduce the cost of small gas turbine engine compressors if the current cast metallic components are replaced with polymer matrix fiber-reinforced composites. Because of the fabrication characteristics, unique manufacturing concepts are required to position the fibers where they will support the loads. At present, all of the processes are performed by manual labor. The project will establish low cost manufacturing technology for the automated fabrication of one piece integrally bladed rotors using organic matrix composite materials for use in limited life, expendable engines.

APPROACH

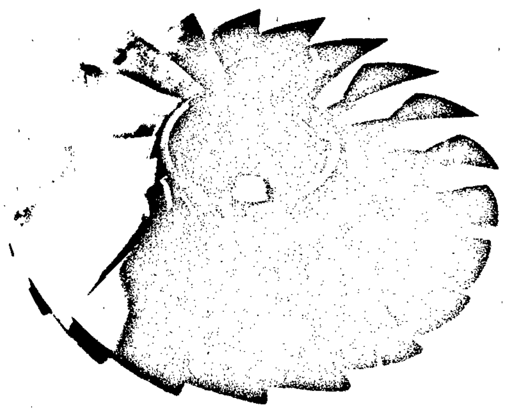
The program will be developed in three phases. In Phase I, Manufacturing Methods Establishment, the design of the Model 373 composite compressor rotor will be modified to accommodate the requirements of an automated robotic winding procedure. Hardware testing will verify that the selected technology satisfies rotor design and engine requirements. Procedures and documentation will be generated to establish the baseline technology approach for consistent quality control in the manufacturing process. A cost study to evaluate cost aspects of the fabrication approach will also be initiated.

In Phase II, Automated Rotor Fabrication and Validation, the automated winding and matrix consolidation tooling will be finalized based on the test results of Phase I. Composite rotors will be fabricated and tested using the final aerodynamic configuration of the modified Model 373 compressor. Rotor testing will include proof spin testing to engine overspeed condition and spin to burst testing.

In Phase III, Automated Rotor Production Demonstration, 30 production rotors will be fabricated, in lots of 10. The automated filament winding and the consolidation of the rotors will be accomplished using the manufacturing and quality control processes and documentation developed and refined throughout the program. Rotors selected from each lot will be bench tested using plink and holography, examined with selected Non-Destructive Evaluation (NDE) techniques and spin/burst tested. This test and evaluation process will verify the reproducibility and demonstrate the readiness of the manufacturing t[illegible]nology for transition to production. A production plan will be finalized and an engine test plan developed. One of the production rotors will be engine tested under separate funding to fully demonstrate the automated manufacturing technology.

BENEFITS

The total manufacturing cost for composite rotors will be reduced. Cost reductions of nearly 30 percent are projected, along with a 20 percent weight reduction. Engine performance and range also will be enhanced.



STATUS

Active
Start Date - August 1988
End Date - November 1992

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Teledyne Corporation

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

COMPOSITES ASSEMBLY PRODUCTION INTEGRATION

CONTRACT NUMBER: F33615-82-C-5012

STATEMENT OF NEED

Composite structures are presently being manufactured by virtually every major aerospace company throughout the country. However, they are still being produced, in many cases, in a very inefficient manner, (hand labor intensive). The industry is still at an early stage of understanding the factory of the future, automated production, planning and associated material and part detail flow through the production shops. Not only is this becoming a major problem at the present time, but as the rate of composite production increases and structures being produced become more complex, the need for automated fabrication and assembly approaches leading towards automated centers becomes increasingly critical. As we move to the next generation of advanced composite aircraft, with more complex and larger structures, the manufacturing and assembly procedures and flow currently being used to fabricate advanced composite structures must be changed. As major portions of aircraft are produced from advanced composite materials, current hand labor or semi-automated approaches associated with the fabrication and assembly of these structures become less and less efficient and in most cases virtually impossible due to size limitations, production rates, quality problems and associated costs.

The objective of this program was to extend the production integration concept to include establishing and validating advanced assembly methods for the efficient manufacture of composite aircraft structures.

APPROACH

This three-phase program was contracted to Northrop Corporation. Phase I generated automation concepts for key elements of composite manufacturing processes and demonstrated the potential production benefits that could be achieved by applying automation Phase II verified the production benefits by fabricating actual composite structures. In Phase III the integrated, computer-controlled manufacturing center was used to fabricate and assemble automatically full-scale composite T-38 wingtips. Production benefits were measured and analyzed to predict the cost savings that can be realized on a full-production run.

During the program, Northrop Corporation established three new automated composite cells in addition to a lamination cell - a cell for automatically dispensing composite prepreg material and removing scrap. One of the new cells is a forming cell for the automated formation of uncured substructural assemblies, such as corrugation stiffeners. Another new cell is an assembly cell for subsequent bonding operations and the joining of various details, such as the accuracy of "pick and place" operation, automated trim and drill cell for automated trimming, and routing and drilling of cured composites. The three cells include automatic-guided vehicles.

BENEFITS

The Composites Assembly Production Integration program demonstrated the possibility and cost effectiveness of the automation of composites assembly. This program produced many industrial "firsts", including automated forming of composite substructure corrugations, a new automatic method for picking up composite plies, and an automatic assembly of aircraft wing tips. Final cost and quality analysis showedf a considerable cost savings in the fabrication and assembly of the T-38 composite wing tips due to the integrated auomated process. A 77% savings on indirect labor hours and a 22% overall dollar savings in total recurring costs of a T-38 composite wing tip were achieved.

STATUS

Complete
Start Date - March 1982
End Date - November 1987
Final Technical Report: AFWAL-TR-88-4072

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: Northrop Corporation

DESIGN AND MANUFACTURING OF LOW COST COMPOSITES

CONTRACT NUMBER: PRDA 90-9-PKRR

STATEMENT OF NEED

The objective of this effort is to develop the integrated design and manufacturing technology necessary to reduce the acquisition and support costs of advanced composite structures for aerospace vehicles. This effort will demonstrate that through the use of new emerging design, analysis and manufacturing technologies implemented through Concurrent Engineering/Integrated Product Development (CE/IPD), it is possible to achieve a 50% reduction in the manufacturing cost of advanced composite aircraft structures.

Future weapon systems will require even greater utilization of composite structures to meet increasing performance and survivability requirements. Composite structures must be reduced in both aquisition and ownership cost to enable future weapons systems to achieve the performance necessary to counter future threats. There is little opportunity to reduce the cost of advanced composite aircraft structures using existing technologies due to limitations in design concepts and methods, material properties and manufacturing processes.

Emerging, innovative new concepts to improve advanced composite manufacturing capability will allow for innovative design techniques to reduce the acquisition cost of composite structures. New structural configurations and design analysis methods need to be developed to utilize these improved manufacturing processes in an appropriate manner.

Experience indicates that decisions made early in the design phase are the most significant cost drivers for the acquisition and support costs of airframe and engine structures. Manufactured cost vs. structural performance design decision databases must be developed to enable future aircraft design teams to make cost effective decisions early in the development cycle. This effort will provide preliminary data for these databases by designing and manufacturing innovative advanced composite structures. Future designers will then have access to verified cost effective design/build methods To assure that decisions have maximum potential to reduce acquisition cost while meeting all pertinent mission requirements, this effort will focus on concurrent engineering CE methods. These CE methods will also help to achieve the most cost-effective match of structural requirements to material properties to manufacturing processes.

APPROACH

This effort is divided into four separate contracts, each representing a different section of the aircraft. The Wing effort will be conducted by McDonnell Douglas Corporation. The Fuselage effort will be conducted by The Boeing Company. The Bonded Wing effort will be conducted by Bell Helicopter Textron, and the Engine effort will be conducted by the General Electric Company.

STATUS

Active
Start Date - September 1991
End Date - September 1996

BENEFITS

The detail component fabrication plan along with the assembly approach by the contractor will provide enough detail to conduct an initial estimate of manufacturing labor, material, and tooling costs. This estimate will be compared to the known data base from the V-22 Full Scale Development (FSD) program. Additionally, tooling costs and material waste percentages will be examined to identify potential cost reductions of up to 50% of the advanced composite aircraft bonded wing, engine and fuselage. Projected benefits are expected from reduced weight, reduced fastener usage, and reduced part count.

RESOURCES

Project Engineer: Paul Pirrung, Diana Carlin, and Kenneth Ronald
WL/MTPN (513) 255-7277
Contractor: McDonnell Douglas, Boeing, General Electric Company and Bell Helicopter Textron

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

NONMETALS

INTEGRATED COMPOSITES CENTER

CONTRACT NUMBER: F33615-85-C-5136

STATEMENT OF NEED

Composite materials have been proposed for advanced aircraft systems, and this trend is expected to continue. Although the number of aircraft and specific applications have not been decided, significant amounts of external surfaces, skins and substructures will be made of composite materials. For current production systems, the technology developed will be used on the F-15, F-18, and AV-8B aircraft. Previous Air Force MANTECH projects have been the stimulus for most of the composite fabrication cells now installed throughout the industry. Benefits analyses have confirmed that substantial cost reductions are realized through automated material handling and lay-up techniques, which reduce manual labor costs. Also, opportunities exist to further reduce total manufacturing costs by introducing computer control and by integrating indirect cost functions such as scheduling, inventory control and data management.

Under this contract, McDonnell Douglas Corporation established a site-specific integrated composites center that reduced aircraft production costs and increased production quality. The design include fabrication of those technology increments that contain a high return on investment: that is, new automation for the shop floor with computer-integrated planning and control systems above the shop floor.

The objective of the Integrated Composites Center (ICC) program was to establish a site specific center that would result in demonstrating a significant reduction in production costs, while at the same time establishing a higher level of quality in both end product and manufacturing performance.

APPROACH

To better integrate the Composites Center, a management team consisting of all the major functional disciplines was established under the responsibility of a single Process Center Director. The ICC system was divided into major, deliverable subsystems configured to provide the Director with a considerable degree of autonomy in the management of the work processed within the composites facility.

Information management and architecture was addressed for a three-tiered hierarchy within the Center: the "enterprise" level, responsible for design and scheduling of the entire aircraft; the "Process Center" level, managing the information vital to the ICC; and the "Shop Floor" level, where the composite parts are manufactured. Application software for all three levels was designed and implemented, using a common data base.

Shop floor processes and equipment were updated and refined. Specific examples include the automated packaging machine, automated ply cutters, ply distribution center, automated core carver, abrasive water jet trimming system, robotic router, and quality interpretation center. These were implemented using a phased approach based on the manufacturing cell concept. Cells were prioritized by the best combination of cost savings potential, production requirements, and disruption factors.

An Industry Review Board was established to evaluate ICC concepts/designs, oversee the implementation of technologies developed, and encourage their use.

In addition, Arizona State University was selected as an independent technology transfer agent for ICC. They developed an implementation guide to enable industry and government to accelerate development and implementation of ICC systems, and designed three graduate-level manufacturing courses around this effort.

BENEFITS

Manufacturing processes are monitored and controlled, and the shop floor is guaranteed work order integrity, improved capability planning, better scheduling integration, and timely delivery of resources to the shop floor.

25% of the cost of manufacturing a composite part is comprised of "touch" labor, and 27% is attriibutable to "non-touch" labor. By addressing both of these areas, ICC is capturing significant savings.

Over 160,000 work orders are processed through the ICC each year for the F-15, F-18 and AV-8B aircraft. Potential savings for these aircraft exceed $95 million.

STATUS

Complete
Start Date - September 1985
End Date - November 1988
Final Technical Report: AFWAL-TR-89-8027

RESOURCES

Project Engineer: Paul Pirrung
WL/MTPN (513) 255-7277
Contractor: McDonnell Douglas Corp.

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

MANUFACTURING TECHNOLOGY FOR ADVANCED BINDER (GAP)

CONTRACT NUMBER: F33615-89-C-5713

NONMETALS

STATEMENT OF NEED

The use of glycidylazide polymer (GAP) in propellants for very large rocket motors will result in environmentally safe devices. When used in formulations for tactical missile propellants and gas generators, GAP results in devices that are less hazardous, have lower flame temperatures, have increased survivability, and are shock insensitive.

The objective of this project is to establish and validate an economical production process for GAP.

APPROACH

This program consists of three phases. Phase I is a Pilot Plant Design and Economic Assessment. Phase II is the Pilot Plant Construction and Evaluation. Phase III is the Plant Operational Demonstration.

The total manufacturing process essential to the establishment of a cost effective manufacturing process for GAP at the pilot plant level will be considered and will be scalable to achieve production rates of 1 to 10 million pounds per year. Emphasis will be on the validation of a production product at the pilot plant scale with the necessary quality assurance and safety controls to meet the established product specifications and environmental requirements. The GAP pilot plant will be capable of producing a quality, marketable product at a rate of 1,000,000 pounds per year.

RESOURCES

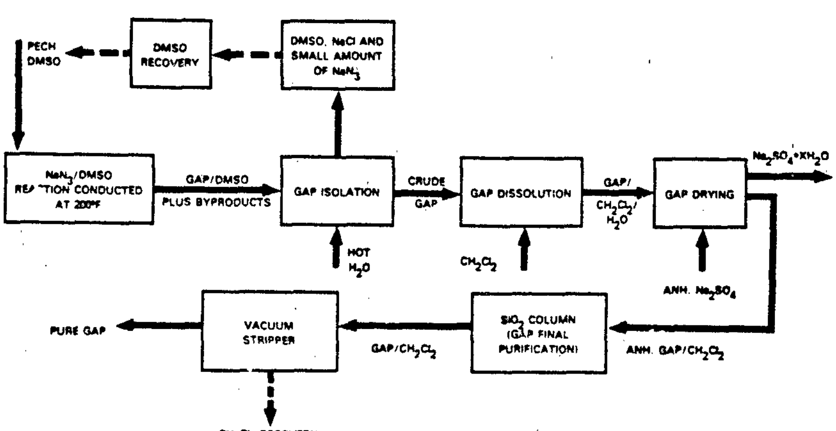
Project Engineer: Ken Ronald
WL/MTPN (513) 255-7278
Contractor: Minnesota Mining & Manufacturing Company

BENEFITS

This program will provide a lower cost product. Based on a recent evaluation of several bench scale processes, the manufacturing cost target of less than \$20/pound is attainable. Comparing this manufacturing cost to the current cost of GAP (\$80+/pound) a cost reduction approaching \$50/pound could be realized. GAP has broad application potential: Class 1.3 non-detonable minimum smoke propellants, clean propellants for solid rocket boosters, gas generators and aircraft starter cartridges, and high performance space propellants for orbital transfer vehicles.

STATUS

Active
Start Date - September 1989
End Date - January 1993



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

REPAIR TECHNOLOGY FOR PRINTED WIRING ASSEMBLIES (PWAs)

CONTRACT NUMBER: F33615-91-C-5700

STATEMENT OF NEED

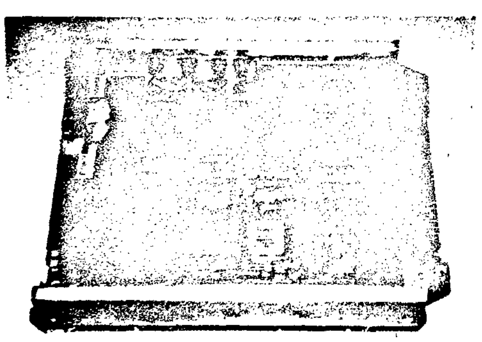
Warner Robins Air Logistics Center (WR-ALC) and Tobyhanna Army Depot (TOAD) are responsible for the repair of non-operational PWAs from a variety of electronics systems. These assemblies come into the depot from the field with defective electronic components. After depot technicians test these assemblies (using Automatic Test Equipment) to identify the failed component(s), the components are removed and replaced. The first step in this operation is the removal of the conformal coating. This manual operation is performed by using abrasive blasting, mechanical abrasion and/or chemicals. The component is then desoldered and removed using either hot gas reflow or a hand held soldering iron. After the assembly is cleaned and inspected, the component is replaced and resoldered. The assembly is then tested, the conformal coating is re-applied, and the assembly is tested again.

As the depots start to see the higher density assemblies with smaller center-to-center spacings and higher lead count, they will require a more controlled, efficient repair system than presently exists using manual soldering. The LANTIRN and SINCGARS (Single Channel Ground and Airborne Radio) systems, which are soon to be organic in the depots, have some of this new technology in their assemblies. Component types on the LANTIRN and SINCGARS assemblies include leaded and leadless Surface Mount Devices (SMDs) as well as through-hole devices. For the SINCGARS System, volume is also a factor; by 1992, 180,000 assemblies will be coming in for repair. An additional area of concern is technician exposure to hazardous chemicals which are used to remove conformal coatings.

The objective of this program is to provide a modular system, which is automated to the extent reasonable, that will (a) identify and locally remove conformal coatings from PWAs, (b) identify and remove failed PWA components, (c) clean the PWA surface prior to the placement of new components, and (d) replace the failed components. This system will be implemented at WR-ALC in the Airborne Electronics Division and at TOAD in the Shops Division.

APPROACH

The program will be separated into four phases. In Phase I, detailed design including depot facilities requirements, computer requirements, and training requirements will be established. In Phase II, the approved design will be fabricated and validated at the contractor's facility, and operator's manuals will be produced. In Phase III, the two systems will be shipped to their locations and installed. In Phase IV, the contractor will remain on site to verify and facilitate integration of the hardware into PWA repair operations.



BENEFITS

- Automation of a largely manual soldering process
- Increased repair efficiency
- Reduced exposure of technicians to hazardous chemicals

STATUS

Active
Start date - July 1991
End date - April 1995

RESOURCES

Project Engineer: Persis Elwood
WL/MTEC (513) 255-2461
Contractor: Westinghouse Electric

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

REPAIR TECHNOLOGY

MANUFACTURING TECHNOLOGY FOR ADVANCED SECOND LAYER NDE SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-81-C-5100

STATEMENT OF NEED

Traditionally, the Air Force has experienced high maintenance and inspection costs associated with aircraft fasteners. Span-wise splice joints between wing skins on aircraft represent a structural configuration in which fatigue cracks can occur in either of the two layers. Currently, only two methods exist for inspecting fastener holes in such structures: 1) the fastener can be removed (a costly and time consuming process) and the hole inspected with a conventional eddy current bolthole scanner or a capacitance probe or 2) a contact ultrasonic method can be used with the fastener remaining installed.

Neither of the two methods is entirely satisfactory. Both the eddy current bolthole scanner and the capacitance probe can detect small flaws, but fastener removal and re-installation is not only a costly process but a potential source of structural damage to the aircraft. Contact ultrasonic inspection is an effective method of inspecting the faying surface of the outer layer, but it is considerably less effective in the fastener countersink region. When a faying surface sealant is present, the ultrasonic technique has the potential for penetration into the second layer; in reality, however, faying surface conditions simply are not adequate for successful ultrasonic inspection of the second layer.

The objective of this program was to apply Low-Frequency Eddy Current (LFEC) technology to an advanced second-layer nondestructive evaluation system designed to detect fatigue cracks initiating in fastener holes on aircraft; the inspection must be performed with the fasteners installed. The flaw detection sensitivity goal for the system was a 0.100-inch radial depth fatigue crack in the second layer, detected repeatedly through various first-layer thicknesses of aluminum, with a variety of different types of fasteners installed.

APPROACH

This program was conducted in three phases: Phase I was devoted to parametric testing which provided the basic capability adaptation and design required to build a prototype unit in subsequent phases. This phase included specific tasks for 1) the optimization of probe sensitivity and reliability as it pertained to detection of second layer defects in wing splice test geometries; 2) investigation of factors affecting probe performance; 3) theoretical analysis of the interaction among drive and sense coils, induced current, and flaws; and 4) construction of prototypes as needed to perform experimental analysis and evaluation in an in-service NDE environment.

Phase II included specific tasks for designing and fabricating a pre-production prototype unit, and advanced parametric testing. Testing focused on evaluating the combined effect of probe off-center, probe lift-off, and fastener head shape in conjunction with second layer flaw detection sensitivity.

Phase III consisted of completing documentation requirements and the design, fabrication and testing of the production units.

STATUS

Complete
Start Date -August 1981
End Date - July 1984
Final Technical Report: AFWAL-TR-85-4095

BENEFITS

This contract resulted in the development of the Model 1705 Low Frequency Eddy Current (LFEC) System which has the following features:

1. Computerized data acquisition for the evaluation of multi-segmented probes. This system has the capability of collecting, analyzing and storing all the required fastener hole data with an inspection speed of 30 seconds per hole. Higher inspection speeds can be obtained by using a faster analog to digital converter (ADC).
2. The potential for the detection of 0.1 - inch second layer flaws through 0.25 - inch first layer specimens ranges from simple bolted parallel aluminum plates to real airframe wing-splice structures with either ferrous or non-ferrous fasteners installed.
3. A precision centering procedure which will allow the operator to accurately center the probe over the fastener hole for inspection.
4. Software algorithms that compensate for variability between the individual pick-up coils.
5. A computer graphic display to provide the operator with a straight forward presentation of detection information. Maximum information is also retained for possible study and interpretation by an experienced operator.

RESOURCES

Project Engineer: Lee Kennard
WL/MTPM (513) 255-4623
Contractor: Systems Research Lab

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ROBOTICS APPLICATION STUDY

CONTRACT NUMBER: F33615-85-C-5053

REPAIR TECHNOLOGY

STATEMENT OF NEED

The five Air Logistics Centers (ALCs) and the Aerospace Guidance and Metrology Center (AGMC) perform major maintenance, repair, and refurbishment operations on Air Force weapons systems. The purpose of the Robotics Application Study was to provide the ALCs and AGMC with an organized systems approach to productivity improvement through automated systems. Major opportunities exist at these six centers for implementing robotics and flexible automation that will enhance both productivity and mission capability. This project provided a roadmap for efficient and cost-effective implementation of new technologies for increased productivity.

The goals of the Robotics Application Study were to: identify, substantiate and recommend potential areas for the application of robotics and automation at the six centers; and to prepare a Robotics Implementation Guide for practical guidance in the implementation of automated manufacturing systems in the ALCs and AGMC.

APPROACH

Areas were identified where the application of state-of-the-art manufacturing technology (including organizational, information systems, expert systems, and robotics technologies) will have significant quantifiable benefit. A top-down methodology utilizing the existing ALC maintenance data base assisted in determining high-payoff robotic and automation opportunities. The resulting Robotics Implementation Guide will be a valuable tool for implementing technologies during the next three to seven years and beyond.

During this 20 month, two phase technical effort, a contractor team visited all six centers several times, conducting extensive on-site interviews and gathering data. Technical and economic analyses were performed to gain full understanding of the automation opportunities unique to each center. Computer models tailored for this study were used to perform the detailed economic analysis of specific opportunities and to prioritize the applications according to their payback potential. Findings and a recommended methodology were included in the Robotics Implementation Guide.

BENEFITS

- First ALC-wide study providing in-depth analysis and practical recommendations for automation
- Top-down system methodology for planning for manufacturing
- Comprehensive Implementation Guide to help transfer recommendations from paper to the shop floor
- Development of software tools for critical economic analysis
- Technology transfer between ALCs/AGMC (military) and the private sector/industrial base

RESOURCES

Project Engineer: Sylvester Lee
WL/MTX (513) 255-7363
Contractor: Honeywell, Inc.

STATUS

Complete
Start Date - January 1985
End Date - June 1989
Technical Operating Report: AFWAL-TR-87-4012

BLADE DISK DISASSEMBLY

CONTRACT NUMBER: F33615-86-C-5012

STATEMENT OF NEED

There is a need to apply advanced technology for more economical and efficient repair of turbine engine components during engine overhaul. When turbine engines are disassembled for class A repairs, the subassemblies are disassembled through various steps to a point where turbine, compressor, or fan wheels have been removed from shaft or hub components. Individual wheels are composed of a disk or hub and attached blades, along with a variety of hardware. Various means are used to constrain blades in the disks according to the engine design. Removal of the blades from the disks or hubs has been limited to simple machines which aid in the removal of tablock plates, and to some specialized hand tools and holding fixtures.

The objective of this program is to establish advanced manufacturing technology to mechanize/automate removal of blades from certain engine disks serviced at both Oklahoma City and San Antonio Air Logistic Centers. This program is part of an overall initiative to establish and implement advanced repair technology at the Air Logistics Centers.

APPROACH

The blade disk and disk assembly machine (BDDM) uses a combination of mechanization, automation, and operator involvement to accomplish the complex disassembly.

The BDDM process removes blades with a high speed impact hammer by aligning the hammer with each blade and striking the blade, which shears the retaining pin. Remnants of the retaining pins are then removed with a pin-removal device.

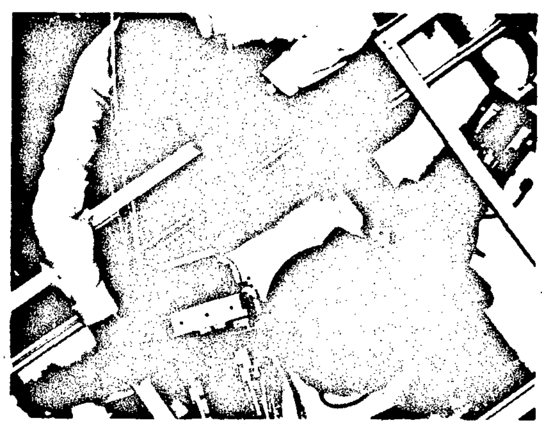
Prompts displayed on the system's video display guide the operator through the removal procedure. A video camera and display accomplish the precise alignment of the machine's electro-impact pin removers. After initial alignment, the system removes the blades and pins automatically. Even though operators are needed for machine setup, the BDDM's repetitive functions are fully automated. Needs analyses and economic assessments were performed for BDDM implementation in 1986, the detailed design was completed in 1987, and the machine was built in 1988. System demonstration and a comprehensive pre-delivery test was performed in January 1989. After the BDDM was delivered to the San Antonio Air Logistics Center (SA-ALC) in February 1989, the system was thoroughly evaluated by the contractor and SA-ALC personnel.

The BDDM was installed at the SA-ALC in May 1989. SA-ALC personnel have been trained in its operation and maintenance. The BDDM has been in successful production ever since.

BENEFITS

The BDDM has reduced cycle time for disk disassembly by more than 75 percent. For example, the T56 sixth stage compressor disk requires 80 minutes for manual disassembly, but 18 minutes by the BDDM.

More importantly, the scrap rate of 35 disks a month has been reduced to zero since the machine went into use. The projected saving from scrap is approximately $300 thousand a year.



STATUS

Active
Start Date - August 1986
End Date - December 1992

RESOURCES

Project Engineer: Siamack Mazdiyasni
WL/MTPN (513) 255-3612
Contractor: Mechanical Technology, Inc.

AUTOMATED / ROBOTIC SHOT PEENING

CONTRACT NUMBER: F33615-89-C-5711

STATEMENT OF NEED

To meet required operating performance requirements, nearly all gas turbine engines rely heavily on proper shot peening technology to greatly enhance the fatigue life of components. Advances introduced to improve existing processes include automated process controls and sensors, robotic part processing, integrated data storage and acquisition.

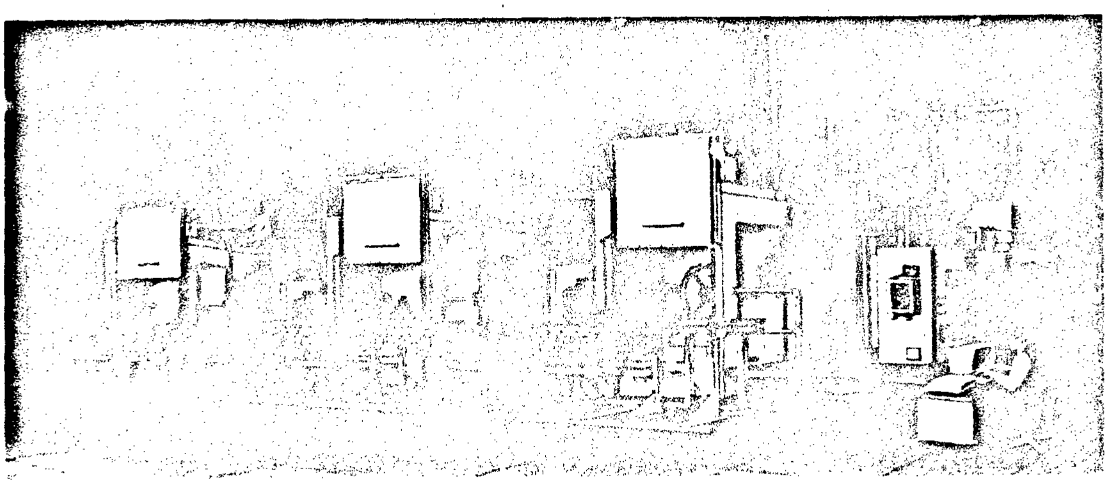
This initiative will introduce automated shot peening capabilities into the San Antonio Air Logistics Center (SA-ALC) to help meet the projected needs of the 1990s. It is part of an overall Air Force MANTECH effort to establish and implement advanced repair technologies for efficient, cost effective overhaul capabilities at the ALCs.

APPROACH

Robotic materials handling and sensor technologies will be established and integrated to effectively demonstrate closed loop control for shot peening. System requirements and needs will be automated; detailed designs will be automated; prototype systems will be fabricated, tested and validated within the contractor's facility; the proven system will be installed at SA-ALC and verified using Air Force personnel and engine components; SA-ALC personnel will be trained to use the system; and assistance in the operation and maintenance of the system will be provided.

BENEFITS

The automated system will not only enable the depot to meet the demands for increased productivity and quality control, but also will improve the environment through a quieter and safer work area.



STATUS

Active
Start Date -September 1989
End Date - January 1993

RESOURCES

Project Engineer: Paul Sampson
WL/MTPM (513) 255-2413
Contractor: Pratt & Whitney / Government Products Division

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

REPAIR TECHOLOGY

AUTOMATED INSPECTION FOR PRINTED WIRING BOARDS

CONTRACT NUMBER: F33615-82-C-5006

STATEMENT OF NEED

Electronic printed circuit boards (PCBs) undergo automated testing from the layout artwork phase, through bare board fabrication, to fully loaded assembly production.

One area of testing needing improvement was the evaluation of the thermal dissipation of the individual components on a PCB assembly. To solve this problem, the Automatic Infrared Test and Inspection System (AITIS), which employs infrared cameras to detect infrared (IR) emission to locate thermal problems, was designed. This system measures the infrared signature radiated by a PCB to determine gross faults. Detectable failures range from active components that are outside acceptable limits (thermally) to shorts and/or missing components on the board.

Every PCB, upon application of power for a specified amount of time, has a unique and repeatable temperature profile.. Heat dissipation can be measured accurately using a scanning infrared camera (IR imager) much the same way a video image is generated. For a video image, reflected light energy is collected from an object, whereas an IR imager measures the energy being generated by the board components. The image can then be compared to a known thermal image, and failures may thus be identified easily and accurately.

The objective of this effort was to design an infrared sensing and image processing system that can look at powered-up printed circuit board assemblies; sense, store and process their thermal image profiles; and display the resultant profile on a 480-line Red, Green and Blue (RGB) pseudocolor monitor. The system must also be able to interface with a host computer for both commands and handshakes, and to process digitized grey scale image data.

The objective of this program was to establish design criteria for a noncontact automatic infrared testing and inspection system for fault isolation of power related problems on printed circuit boards and on wired assemblies.

APPROACH

The program included two phases. Phase I activities included (1) design and develop prototype hardware and software specifications; (2) establish system performance characteristics unique to the Air Logistics Center (ALC) operating environment; (3) develop an Infrared Imager and associated Digital Image Processor to maximize system performance; (4) evaluate the design specifications and system performance; (5) assemble and deliver a prototype system.

Phase II activities included (1) install the system and train the operating personnel in the selected ALC; (2) demonstrate system capabilities and performance at McClellan AFB to acquaint potential users in a repair depot and manufacturing environment; (3) prepare manufacturing and technology transfer plans for the system.

The major components of the system are a host computer, removable mass storage, programmable power supplies, a programmable switching matrix, a video recorder, an IR image processor, a color video monitor, an operator console (terminal), a PCB adapter and a positioning mechanism.

BENEFITS

The AITIS performs thermal testing of PCB assemblies automatically and quickly. The average required time of three to six minutes per test includes operator set-up time, stored image retrieval, power-on time, and failure determination.

Gross faults are easily detected by the AITIS. Boards operating at temperatures above normal indicate potential long-term problems. The boards that showed operational problems, such as noise threshold or signal level problems, did not cause a thermal fault and did not appear on thermograms.

Analyses indicated that a maximum test time of 6 minutes would be required for a single board.

STATUS

Complete
Start Date - September 1982
End Date - June 1987
Final Technical Report: AFWAL-TR-86-4001

RESOURCES

Project Engineer: Donnie Saunders
WL/MTE (513) 255-2461
Contractor: Hughes Aircraft Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

LARGE AIRCRAFT ROBOTIC PAINT STRIPPING (LARPS)

CONTRACT NUMBER: F33615-91-C-5708

STATEMENT OF NEED

Organic finish systems for aircraft are formulated to provide environmental protection to external surfaces which are susceptible to corrosion, rain and/or solid particulate erosion. These coatings must have sufficient durability to sustain protection between scheduled overhaul periods. Aircraft coatings are subjected to temperature extremes, abusive damage during unscheduled maintenance, and exposure to ultraviolet radiation. These tightly adherent and durable coatings (paint) must be completely removed during programmed depot maintenance (PDM) because of paint deterioration, surface damage, coating build-up from touch-up painting, and need for access to bare aircraft surfaces to facilitate non-destructive inspection. The inherent toughness and durability of these coatings makes their stripping or removal difficult and expensive. The Air Logistics Centers currently remove organic coatings from aircraft with methylene chloride based chemical stripping compounds followed by mechanical abrasion, if necessary, to remove any residuals. Chemical stripping has several disadvantages: (1) process time is slow;(2) chemicals are expensive;(3) personnel are exposed to a hazardous environment;(4) chemicals cause premature degradation of the working areas; and (5) special disposal techniques are required to minimize the environmental impact of the effluent.

APPROACH

The program will be performed in three phases. Phase I involves establishing system needs; implementation schedule; facility, supportability and interface requirements; cost benefits; system design based on current and projected workloads as well as aircraft size; individual part configuration; process optimization; validation of process acceptability; preliminary design; and detailed design. A Phase I milestone will be a preliminary design review in which system viability will be demonstrated. Phase I will continue into the detailed design of the LARPS system, validation of system design against performance requirements, establishment of training requirements, review of technical orders (TO's), revised implementation schedule, system cost projections, test plans and training plans. Phase I will culminate in a detailed design review.

Phase II encompasses fabricating an automated, robotic paint stripping cell using design data generated in Phase I. Factors such as aircraft type, aircraft size envelope, manipulator accuracy, robot control, fault diagnostics, system supportability, facility interface requirements, as well as worker and environmental safety will be considered in devising the system layout. Phase II will culminate with system acceptance testing and operator training conducted at the contractor's facility.

Phase III will consist of system installation and validation at Oklahoma City Air Logistics Center (OC-ALC). Designated aircraft and aircraft components will be stripped in an automated mode. A subsequent evaluation will be conducted using existing test methods/standards to confirm system capabilities with performance requirements.

BENEFITS

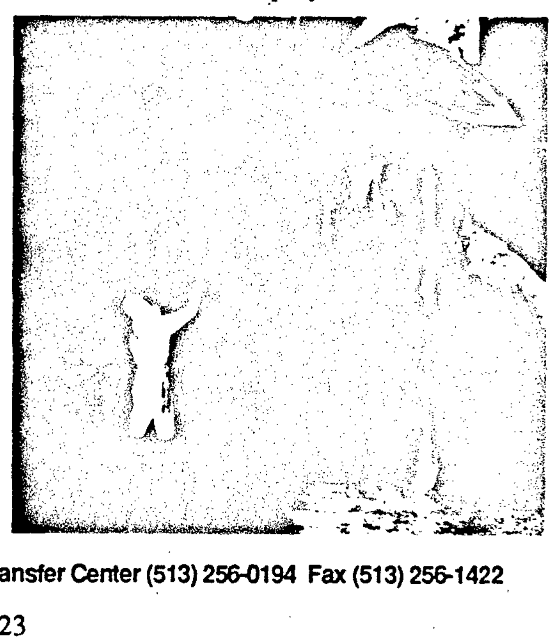
This program will establish an automated stripping process with the following characteristics: reduced aircraft preparation, clean-up, and depaint manhours; reduced depot flow time; reduced ALC personnel exposure to the extremely hazardous work environment; lower cost; and a significant reduction of toxic/hazardous waste produced.

STATUS

Active
Start Date - June 1991
End Date - January 1995

RESOURCES

Project Engineer: David See,
WL/MTPM (513) 255-5037
Contractor: United Technologies Corporation/
USBI Company



For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ROBOTIC FUSELAGE TANK DESEALING (RFTD) SYSTEM

STATEMENT OF NEED

CONTRACT NUMBER: F33615-88-C-5431

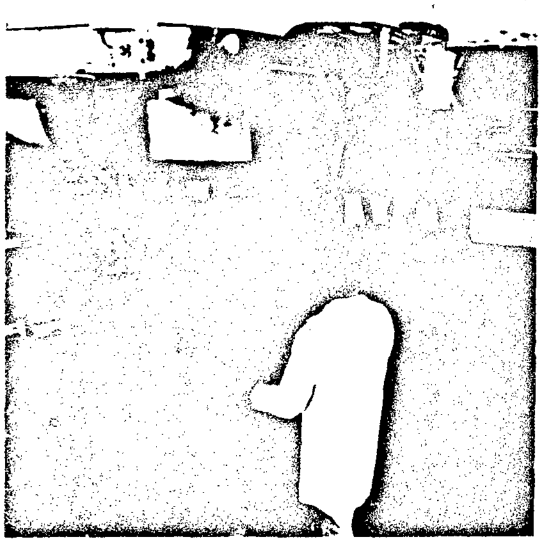
A fuel leaking problem in F-111 aircraft fuselage tanks is a result of a polyester based faying surface sealant that was applied to the aircraft where the structure was overlapped and riveted. A polysulfide coating was then put over the sealant. After the systems were fielded, the sealant reverted and reacted with the polysulfide coating and caused leakage. The repair consists of removing as much of the degraded sealants as possible (using chemicals, 8000 PSI water picks, and hand picks), then putting down a thin bead of epoxy to try and contain the faying surface sealant. A polysulfide coating is then put over the epoxy.

The current deseal procedure involves soaking the sealant with chemicals for 24 hours for softening. Water picks then are used to remove as much of the sealant as possible. Any remaining sealant is removed by hand. The deseal operation is very labor intensive and hazardous because of the nature of the repair process. Rework is often required.

The objective of this program is to provide a robotic based system for the removal of sealant from the inside of fuselage fuel tanks on F-111 aircraft serviced at the Sacramento Air Logistics Center (SM-ALC). This is part of an overall Air Force manufacturing technology effort to establish and implement advanced repair technology (REPTECH) for efficient, cost effective overhaul capabilities at Air Force Logistics Command Air Logistics Centers (ALCs).

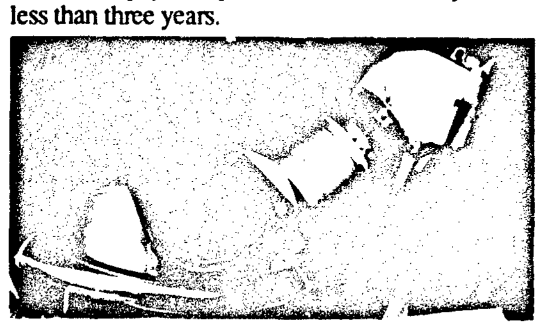
APPROACH

This effort addresses the use of robotic systems removing of polysulfide sealant, epoxy barrier, and reverted polyester material from the interior of the fuselage fuel tanks on the F-111 aircraft. This program will deliver a robotic system, incorporating the integration of vision systems, sensors, and remote operation control capability.



BENEFITS

The RFTD system has been designed to address all of the safety issues as well as reduce the costs involved in F-111 desealing. The system will remove more than 75% of the sealant in all of the fuel cells, greatly reducing the time ALC personnel are in this dangerous and severe environment. Medical and safety expenses are reduced by an estimated 82%. Materials and life support costs are lowered by an estimated 85%. The RFTD system has reduced the total costs per fuselage from $160,500 to $68,100, saving a total of $92,400 for each fuselage processed. Larger savings would be realized if more than one RFTD system is purchased and installed by SM-ALC. The payback period for one RFTD system is less than three years.



STATUS

Active
Start Date - October 1988
End Date - June 1992

RESOURCES

Project Engineer: David See
WL/MTPN (513) 255-7361
Contractor: Northrop Corporation/Aircraft Division

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

STATIC AND ACCESSORY REPAIR PROGRAM / ADVANCED REPAIRS FOR STATIC COMPONENTS

CONTRACT NUMBER: F33615-87-C-5271

STATEMENT OF NEED

Some of the gas turbine engines falling within the responsibilities of the Oklahoma City Air Logistics Center (OC-ALC) are very old. For example, the J-57 series engine has been in service for 30 years. As gas turbine engine components age, the mechanical and physical properties degrade due to thermal cycling, multiple repairs, and/or corrosion. Depending on the service history and alloy, reduced properties result from carbide precipitation, grain growth, grain boundary segregation, formation of undesirable microstructure, and increased residual stress. The result is warpage, reduced tolerance to weld repair, reduced ductility, and increased susceptibility to fatigue cracking. Current procedures involve subjecting the component to multiple repair attempts and, if are all unsuccessful, replacement with a new item. However, in the case of older engines, new components may not be available, and the only recourse is to retire the engine.

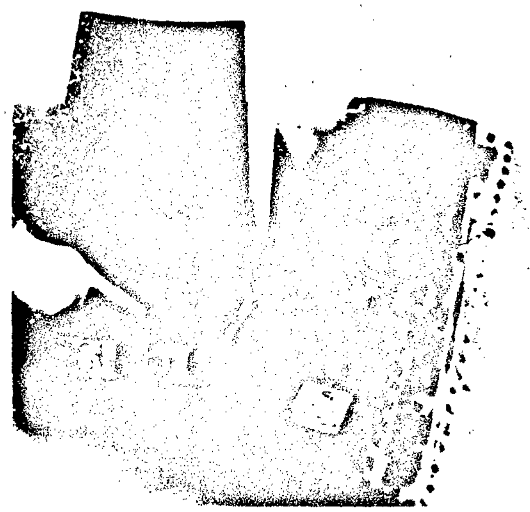
The objective of this task is to establish procedures to rejuvenate engine components rejected as a result of reduced physical/ mechanical properties and not repairable using current repair procedures. Processes and procedures such as hot isostatic pressing, heat treatment, pre/post weld thermal cycling, high temperature diffusion brazing, vibratory stress relief, plasma spraying, and machining will be established to accomplish the rejuvenation. The tested and validated system will then be installed at OC-ALC.

APPROACH

This effort consists of needs analysis; conceptual and detailed design; system assembly, implementation and verification; and personnel training at the OC-ALC. Phase I consists of a needs analysis of the rejuvenation cell concept. Suitable components for rejuvenation will be established based on cost effectiveness, return on investment, impact of fleet readiness, and suitability for rejuvenation. Phase II consists of constructing the improved optimized cell based on the needs analysis. The system will then be tested to document the results of rejuvenation. An initial training of ALC personnel will also occur. Phase III consists of installation of the cell at OC-ALC, training of maintenance and operation personnel, plans for technology transfer to industry, DoD and finally documentation of economic gain.

BENEFITS

This program has the potential to reduce scrap by 50%. It provides new repair technologies to the Oklahoma City Air Logistics Center, and will save the Air Force an estimated $9.5 M annually.



STATUS

Active
Start Date - June 1987
End Date - September 1992

RESOURCES

Project Engineer: David See
WL/MTPM (513) 255-3612
Contractor: General Atomics

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

STATIC AND ACCESSORY REPAIRS / ROBOTIC ENGINE MANIFOLD CLEANING CELL

CONTRACT NUMBER: F33615-87-C-5271

STATEMENT OF NEED

Current engine repair processes for static and accessory jet engine components such as frames, cases, fuel manifolds and tubing are inadequate. These processes result in excessive rework, long turnaround times and high labor costs. As a consequence, many repairable components are being scrapped that could be repaired if improved processes were available.

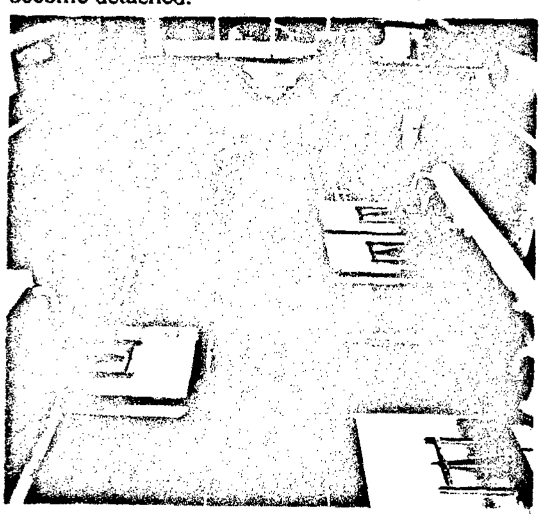
An important part of aircraft maintainence is the removal of carbon (or "coke") deposits from engine-manifold parts which build up and restrict fuel flow into the combustion chamber, severely affecting engine performance and efficiency. In some instances, deposits can break loose during engine operation and cause valve seats to jam open, resulting in engine "burn out".

The standard process for removing the accumulated coke deposits has been chemical oxidation using a hot (190°F) concentrated solution of potassium permanganate and sodium hydroxide pumped through the engine manifold parts. Over the years, this cleaning method has evolved into a large-scale activity at the Oklahoma City Air Logistics Center (OC-ALC), but the fundamental "hands-on" operating techniques remain the same. These manual techniques involve loading uncleaned parts into fixtures and containers, inserting the parts into tanks of hot cleaning solution, and retrieving, rinsing, drying, and inspecting the cleaned parts.

APPROACH

The functions of the robotic engine manifold cleaning cell (EMCC) are designed to remedy all of the shortcomings of the current process. The parts are received from inventory and manually installed on fixtures at workstations that are a safe distance from the chemical processing work cell. The loading fixtures move into the cleaning cell by an input conveyor, controlled by the supervisory computer. Once inside the cell, which is off limits to all personnel when activated, the loaded fixture is transported from the input conveyor into wash tanks, rinse tanks, and an output conveyor for removal from the cell.

The advanced pumps, designed for easy changeout and maintainability, deliver hot cleaning solution to the internal sections of the parts under high pressure, typically flowing in the reverse direction of fuel flow to remove any coke and scale particles that may become detached.



New Procedure

BENEFITS

- $1.02 M savings to the Air Force annually
- 100% elimination of hazardous waste
- Maintenance of peak cleaning effectiveness at all times
- Reduction of process material cost by 95%
- Removes personnel from hazardous environment

Old Procedure

STATUS

Active
Start Date - April 1989
End Date - March 1993

RESOURCES

Project Engineer: David See,
WL/MTPM (513) 255-5037
Contractor: General Atomics

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

ADVANCED COMPUTED TOMOGRAPHY (CT) BASED NDE SYSTEM PRODUCIBILITY

CONTRACT NUMBER: F33615-81-C-5012

STATEMENT OF NEED

The aerospace industry is continually searching for the most efficient method of inspecting components to assure freedom from defects which degrade performance and to evaluate the in-process condition of components being manufactured. Visual, ultrasonic, and radiography are the most commonly used methods. For components with thick or complex wall structures, film or real time radiographic techniques have been widely employed. A major shortcoming in these radiographic techniques is the superpositioning of image data, when two or more points of inte: st lie along the same ray path. Changing dimensions or densities along the ray path are major sources of film interpretation errors. Computed Tomography (CT) images are free of this superpositioning and the resultant subjective interpretation of film. CT ray paths pass through every point on a plane through a component from multiple angles, and the computer mathematically reconstructs a cross-sectional image of the component.

APPROACH

Computed Tomography technology was successfully transitioned from a medical diagnostic tool to a viable industrial inspection and evaluation tool for missile and rocket motor hardware/ components. Design and construction techniques were established and used to fabricate two CT systems: Air Force Advanced Computed Tomography System - I (AFACTS-I) and Air Force Advanced Computed Tomography -II (AFACTS-II). AFACTS-I used a 420 KV radiation source and is capable of the rapid inspection of rocket motors and other complex structures up to 1 meter (39 inches) in diameter with X-ray attenuations equivalent to 10 cm (4 inches) of steel or less. AFACTS-II uses a Linatron L-6000 16 MeV radiation source and is capable of the rapid inspection of large rocket motors and complex structures up to 2.5 meters (98 inches) in diameter with X-ray attenuations equivalent to 40 cm (16 inches) of steel or less.

Both AFACTS-I and II have been demonstrated on calibration and proof standards and a large variety of live and inert rocket motor and other aerospace components. AFACTS-I has been used in various inspection and engineering diagnostic roles in support of a wide variety of DoD and NASA projects including Minuteman, Peacekeeper, SRAM-A, PAM-D, GAU-8, SPARTA, Sparrow, Sidewinder, Small ICBM, Naval Air R&D, and Aerojet IR&D.

BENEFITS

The advantages of CT over other radiographic methods are summarized as follows: absence of superpositioned structures in the image; quantitative volumetric density and spatial dimensional measurements; views that locate, orient, and size components in three dimensions; superior contrast resolution; large dynamic range; digital data base; and computer image processing.

For production motors the inspection time is reduced, the cost of film (Peacekeeper is $3,000/ motor), is reduced and more information is available than with film.

For aging motors a possible reduction exists in the number of required motor dissections.

There is a new data base for future studies such as chemical migration with time, strain measurements in propellant grains, burn rate characterization (aluminum concentration data), mechanical properties and CT data correlation, and dual energy for chemical composition (aluminum or plastic).

STATUS

Complete
Start Date - January 1981
End Date - January 1989
Final Techical Report: AFWAL-TR-89-8016

RESOURCES

Project Engineer: Timothy Swigart
WL/MTPM (513) 255-2413
Contractor: Aerojet Solid Propulsion Company

For More Information Contact The Technology Transfer Center (513) 256-0194 Fax (513) 256-1422

REPAIR TECHNOLOGY

INTEGRATED BLADE INSPECTION SYSTEM (IBIS) II PART A, INFRARED MODULE

CONTRACT NUMBER: F33615-80-C-5106

STATEMENT OF NEED

Many high pressure turbine blades have internal passages and surface cooling holes that allow convective and film cooling of the parts. Any reduction in this cooling can result in overheating of the affected area and premature failure of the part.

New automated inspection modules have been established, built and tested which address key airfoil inspection processes. One of these is the inspection of air-cooled turbine blades for cooling efficiency. Inspection for cooling efficiency is an important requirement which is currently accomplished by airflow and waterflow measurements. These current techniques, although adequate, are time consuming and subject to certain difficulties in the subjective interpretation of results.

This infrared inspection process is based on a computerized analysis of infrared thermal transient images of airfoil surfaces following a sudden injection of hot air into the airfoil. This inspection process is the basis of an automated infrared inspection module (IRIM) to inspect air-cooled turbine airfoils for cooling efficiency.

The objective of this Part A project was to establish, build, and test a production-type IRIM, which reliably and repeatably inspects used and new air-cooled gas turbine engine blades for cooling efficiency. The IRIM is intended to be a computer driven device that automatically conducts all phases of its inspection process.

APPROACH

This IBIS-II project consisted of five phases. During Phase I, the IRIM was established, built, and proof tested at General Electric Aircraft Engines in Evendale, Ohio. In Phase II, the infrared design and inspection criteria were verified and established. In Phase III, the IRIM was operated, proof-tested, and demonstrated as part of the IBIS Information Computer System (ICS). During Phase IV, the IRIM was installed and checked at the San Antonio Logistics Center (SA-ALC) blade inspection facility. In Phase V, the software capability of the IRIM was expanded by adding a new blade type to the IRIM and ICS at the General Electric facility and the SA-ALC blade inspection facility. Samples of this blade were then inspected to demonstrate the ability to inspect additional single and/or dual air-cooled turbine blade types.

STATUS

Complete
Start Date -September 1980
End Date - July 1989
Final Technical Report: WRDC-TR-89-8029

BENEFITS

A new, automated, quantitative, infrared inspection process was designed to replace waterflow inspection techniques and to improve the accuracy and speed of inspections over the current manual procedures.

RESOURCES

Project Engineer: Timothy Swigart
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Contractor: General Electric Company

INTEGRATED BLADE INSPECTION SYSTEM (IBIS) II PART B, X-RAY INSPECTION MODULE

STATEMENT OF NEED

CONTRACT NUMBER: F33615-80-C-5106

The manufacture of high-performance fuel efficient aircraft turbine engines has led to the development of turbine blades containing complex interior passages and openings in blade surfaces for cooling. The performance and life of blades is dependent upon the precise manufacture of these interior structures. A high penalty exists for blade failure, such as machine damage, mission failure, and hazards to personnel. For these reasons, 100 percent inspection of turbine blades is important to both government and industry. Jet engine turbine blades and vanes are presently inspected for internal casting flaws and cooling passage integrity using conventional film radiography.

The X-ray procedure consists of three operations: radiographic exposure of the part and the film, film processing, and film reading to ascertain the quality of the part. Operations are performed manually with the exception of automatic film processing. Structural features that cause variations in absorption and X-ray paths affect the density of the film image. These film images are then interpreted visually by an operator.

The current inspection procedure is labor intensive, and substantial material costs are incurred for X-ray film and processing chemicals. The reliability of this inspection process is dependent on the judgement of inspectors who are influenced by their experience, visual acuity, fatigue, and physical and emotional state. Furthermore, the results are affected by process variables, including the sensitivity tolerances of a given grade and batch of film, the tolerances of processing chemicals, trial and error refinement of film developing time to adjust for these variables, and film exposure criteria such as voltage, current, and time.

The objective of IBIS II-Part B was to establish, build, and test a production prototype X-ray inspection module (XIM) providing Computed Tomography (CT) and digital fluoroscopy inspections on new gas turbine engine blades and vanes.

APPROACH

This project involved the establishment, construction, testing, and demonstration of the XIM at the General Electric Aircraft Engines facility in Schenectady, New York and consisted of four phases. In Phase I, a performance specification for the XIM was prepared, and subassembly designs were established. In Phase II, the X-ray subassembly, including loader and manipulator, were built and tested. In Phase III, the computer subassembly for performing high speed tomography, reconstructions, digital fluoroscopic reconstructions, and flaw detections was built, programmed, and tested. In Phase IV, the XIM was integrated, tested, demonstrated, and installed in the General Electric Aircraft Engines facility in Evendale, Ohio. Any deficiencies found in the XIM relative to specification requirements were corrected. The XIM was then retested to confirm its compliance with performance specifications and with validation test plans and measurements. Additional dimensional characteristics will be added to the inspection requirements as needs are identified.

BENEFITS

Two XIM's are now operational: a productionized version of the XIM established on this project and a second unit.

Both units are being used for in-process inspections, including part internal wall thickness measurements. The XIM's are providing valuable in-process feedback information for manufacturing operations. The XIM's are also being used for the disposition of parts that have been held pending the resolution of various flaw images that could not be adequately characterized with conventional film X-ray. The XIM's CT mode provides additional part cross-sectional information that allows a more complete characterization of the nature, size and location of apparent flaws. The XIM system is planned to be used for all X-ray inspections, including final inspection.

The XIM system has demonstrated that a filmless X-ray system is feasible from economic, quality and production standpoints. In addition, the system has demonstrated that dimensional functions can be determined, measured and used for process control.

STATUS

Complete
Start Date - September 1980
End Date - July 1989
Final Technical Report: AFWAL-TR-87-4135

RESOURCES

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REPAIR TECHNOLOGY

INTEGRATED BLADE INSPECTION SYSTEM (IBIS) II PART C, AUTOMATED FLUORESCENT PENETRANT PROCESSING MODULE

CONTRACT NUMBER: F33615-80-C-5106

STATEMENT OF NEED

Fluorescent penetrant inspection (FPI) is one of the most widely used nondestructive inspection (NDI) methods at the Air Logistics Centers (ALCs) and throughout the aerospace industry. Any improvements in the process that would provide better control and/or that would reduce processing time, while maintaining or improving sensitivity, would be a benefit.

Present fluorescent pentrant processing is generally very labor intensive and subject to operator subjectivity and resulting errors.

The objective of this project was to establish, build, test, and install advanced turbine blade inspection modules that offer significant improvements over conventional blade inspection techniques. Another purpose was to determine specific facility requirements and to build, test, and install additional turbine blade inspection modules and IBIS information computer systems for other military users.

The objective of this Part C effort was to establish, build, and test a production-type automated fluorescent penetrant processing module (AFPPM) that reliably and automatically applies fluorescent penetrant material to single turbine engine blades and vanes.

APPROACH

Phase I included the preparation of performance specifications and validation test plans for the AFPPM, singularly and in collaboration with the FPI process developed in another Air Force program. During Phase II, the AFPPM was procured, monitored, constructed, transported and installed at the Sacramento ALC. Validation testing was conducted at the ALC and at the General Electric Aircraft Engines facility in Evendale, Ohio.

BENEFITS

Automatic fluorescent penetrant processing systems offer the following benefits to aircraft overhaul facilities:

- Improved overall reliability and consistency of the penetrant application process for general aircraft engine overhaul using fluorescent penetrant inspections.
- Improved compatibility of the processed parts with the fluorescent penetrant inspection.

STATUS

Complete
Start Date - September 1980
End Date - July 1989
Final Technical Report: WRDC-TR-89-8024

RESOURCES

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NONDESTRUCTIVE EVALUATION (NDE) SYSTEM FOR RETIREMENT FOR CAUSE

CONTRACT NUMBER: F33615-81-C-5002

STATEMENT OF NEED

Historically, methods used for predicting the life of gas turbine engine rotor components have resulted in a conservative estimate of useful life. Most rotor components are limited by low cycle fatigue (LCF), generally expressed in terms of mission evaluation equivalency cycles or engine operational hours. When some predetermined life limit is reached, components are retired from service. A need exists to develop and integrate materials behavior characteristics, component life analysis, nondestructive evaluation and cost-risk assessment technology to establish and demonstrate the retirement for cause maintenance concept as it applies to rotating components of military gas turbine engines. This provides the basis for eliminating of classical cyclic, or time life requirements, currently imposed on gas turbine rotor components by substituting a system in which each individual component is retired from service when the economical, safe life of that component is exhausted. In this system, the retirement of a component from service would occur when the unique cyclic life of that component has been utilized, as opposed to an arbitrary cycle or time count on which the entire population of components of a specific type are retired, regardless of condition.

The objective of this program is to establish an integrated and generic Nondestructive Evaluation (NDE) system required for implementing a retirement for cause (RFC) methodology for F101, F110 and F100 engine components in the San Antonio Air Logistics Center (SA-ALC). The implementation of RFC has been expanded to include General Electric engines overhauled at the Oklahoma City Air Logistics Center (OC-ALC).

APPROACH

Phase I has provided the validation of NDE technologies for system incorporation. Phase II has established the system requirements, constructed a prototype and evaluated its performance. Phase III has included the manufacture of production type systems. Phase IV has implemented the system at SA-ALC and is nearly complete. New efforts related to F-101 and F-110 engine components overhauled at OC-ALC are more than half underway.

The system is modular, uses standard communication interfaces, and has extensive computer capability for flexibility and expandability. The system consists of five eddy current and two ultrasonic inspection stations and an operator console controlled by two VAX 11/780 computers. The computers perform advanced data processing, system interface, and flaw signal analysis and allow for retention of historical flaw data for each engine component inspected.

BENEFITS

The benefits of this program include:

- Increased engine availability
- Fewer required spares
- F100 Engine
  - Projected $1 billion overhaul cost savings
  - Projected savings of 6 million pounds of critical/strategic materials
  - 25:1 return on investment
- F101 & F110 Engines
  - Results similar to the F100 application are expected.

STATUS

Active
Start Date - September 1980
End Date - September 1991

RESOURCES

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ROTOR STACKING PROCESS

CONTRACT NUMBER: F33615-82-C-5093

STATEMENT OF NEED

The objective of this program is to establish a Rotor Stacking Process Cell (RSPC) to increase efficiency in the repair and assembly of TF-30 gas turbine engine rotors at the Oklahoma City Air Logistics Center (OC-ALC) through the use of vibration prediction diagnostics during rotor assembly.

APPROACH

This program will consist of the establishing and implementating automated inspection techniques integrated with a computer controlled parts inventory and kitting system. Major rotor components will be inspected as the rotor is disassembled, and critical physical measurements will be computer analyzed to determine each specific repair sequence necessary to return the component to a serviceable condition. Non-repairable parts will be discarded, and the others will be repaired. After overhaul, each component will be re-inspected to certify serviceability and to input its critical physical measurements into a parts inventory and kitting system computer. When the need for a rotor kit is generated, the computer will analyze the available inventory to identify the best combination of components and the relative component orientation to be used in the rotor buildup to minimize engine vibration.

BENEFITS

The benefits of this program include a potential annual savings of $4.5 M/year for TF30 engines, and increased quality and productivity in gas turbine engine repair.

STATUS

Active
Start Date - April 1982
End Date - October 1991

RESOURCES

Project Engineer: Timothy Swigart
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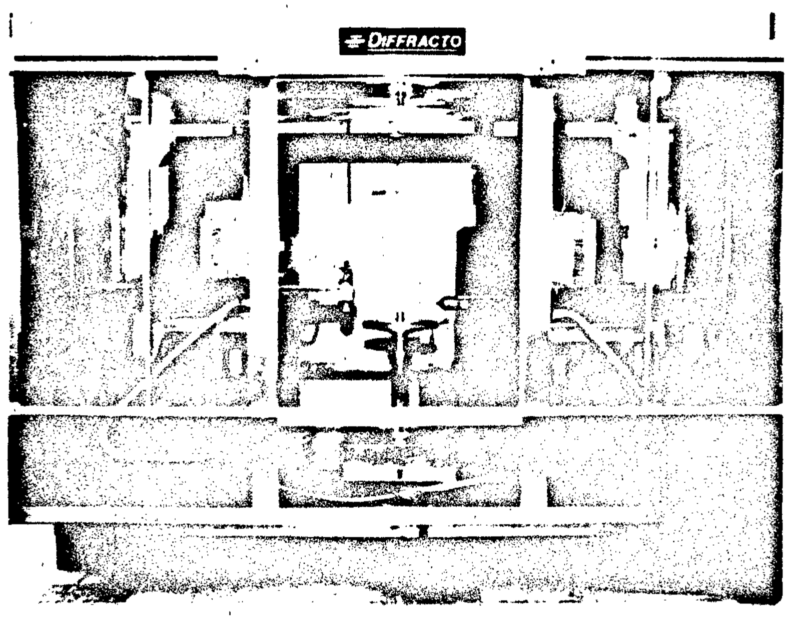
Contractor: Mechanical Technology, Inc.



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EDDY CURRENT SURFACE INSPECTION OF DISKS

CONTRACT NUMBER: F33615-80-C-5143

REPAIR TECHNOLOGY

STATEMENT OF NEED

Aircraft engine components are designed to meet or exceed some specified service life. This life is established for each component in the engine, and is dependent upon the part material, geometry, and service conditions. As an engine line matures, more empirical evidence is available to support the predicted life. Much of this evidence is based simply on the incidence (or lack) of part failure in the field. This can be used to statistically infer a minimum failure life of the part. More desirable from a flight safety standpoint is information on part condition, and particularly on when cracks first initiate in a part. For this data, some form of non-destructive evaluation (NDE) is needed.

The objective of this program was to design, fabricate, test and deliver two automated pre-production eddy current scanning systems for inspecting engine rotating parts.

APPROACH

The program was divided into three (3) tasks. The first task was to further evaluate the prototype system established under contract F33615-78-C-5097, and to define a pre-production system. The second task was to fabricate, test, and demonstrate two of these systems. The third task was to install and check out the two systems at Air Force Air Logistic Centers (ALCs). The check-out included a four (4) month field evaluation test, aimed at establishing system reliability and repeatability. Additionally, an orientation program was conducted for ALC personnel.

All these tasks have been completed, with one system being installed at the San Antonio Air Logistic Center (SA-ALC) and one at the Oklahoma City Air Logistic Center (OC-ALC). System capabilities include the following:

- Reproducible detection surface connected flaws .030 inch long by .005 inch deep with a signal-to-noise ratio of two (2) or more.
- Automatic identification of the location of detected flaws.
- Inspection of turbine aircraft engine rotating part features such as bores, boltholes, dovetails, and fillet radii.
- Fully automated calibration, scanning, signal processing, data storage, decision making, hardcopy reports, and indication evaluation.

BENEFITS

Improvements over manual inspections have been estimated at 70% for calibration time, 40-60% for inspection time, and 40-60% for report paperwork.

Preliminary data indicate that system "up time" will be in excess of 80%, while the system variability will typically be less than 15%.

STATUS

Complete
Start Date - September 1980
End Date - February 1984
Final Technical Report: AFWAL-TR-83-4151

RESOURCES

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